California Environmental Protection Agency

Air Resources Board

Public Hearing to Consider Proposed Amendments to the
California Regulations Governing the:

HEAVY-DUTY VEHICLE INSPECTION PROGRAM

PERIODIC SMOKE INSPECTION PROGRAM

October 1997

Prepared by the

Mobile Source Operations Division
Heavy-Duty Diesel Branch

Mail Out: MSO 97-09

TITLE 13. CALIFORNIA AIR RESOURCES BOARD

NOTICE OF PUBLIC HEARING TO CONSIDER ADOPTION OF REGULATORY AMENDMENTS TO THE CALIFORNIA HEAVY-DUTY VEHICLE INSPECTION PROGRAM AND PERIODIC SMOKE INSPECTION PROGRAM

The Air Resources Board (ARB) will conduct a public hearing at the time and place noted below to consider adoption of regulatory amendments to the California Heavy-Duty Vehicle Inspection Program (HDVIP) and Periodic Smoke Inspection Program (PSIP).

Date:	December 11, 1997
Time:	9:30 a.m.
Place:	Bay Area Air Quality Management District 939 Ellis Street 7th Floor Board Hearing Room San Francisco, California 94109

This item will be considered at a two-day meeting of the Board, which will commence at 9:30 a.m. on December 11, 1997 and may continue at 8:30 a.m. on December 12, 1997. This item may not be considered until December 12, 1997. Please consult the agenda for the meeting, which will be available at least 10 days before December 11, 1997, to determine the day on which this item will be considered.

INFORMATIVE DIGEST OF PROPOSED ACTION/PLAIN ENGLISH POLICY STATEMENT OVERVIEW

Sections Affected: California Code of Regulations, title 13, sections 2180 through 2188, and sections 2190 through 2194.

The existing HDVIP regulations. The HDVIP regulations establish a program in which heavy-duty vehicles are tested by ARB inspectors at various roadside locations to identify vehicles that emit excessive smoke or have defective or tampered emission control systems. The opacity of smoke from diesel engines is measured in accordance with a "snap-acceleration" stationary vehicle test procedure that uses an electronic smokemeter and is based on the Society of Automotive Engineers (SAE) SAE J1243 procedure. The regulations require that smoke emissions from heavy-duty engines not exceed smoke standards of 55 percent opacity or 40 percent opacity, depending primarily on the year, make and model of the vehicle being tested. A visual inspection is also conducted. The owners of vehicles failing the smoke test or inspection are issued citations which require the timely repair of the vehicle and carry civil penalties ranging from $300 to $1800 per violation. The repair is documented by a "demonstration of correction" submitted to the ARB. Vehicle owners may appeal citations through the ARB's administrative hearing program, established in sections 60075.1 through 60075.47, title 17, California Code of Regulations.

The HDVIP regulations were adopted following a November 1991 hearing, in response to directives in Health and Safety Code section 44011.6, enacted in 1988 by Senate Bill (SB) 1997 (Stats. 1988, ch. 1544, Presley). The regulations became operative on November 21, 1991 and the program was actively enforced until October 15, 1993. During this time, the failure rate was reduced from 34 percent to 21 percent, resulting in an estimated 38 percent reduction in the number of excessively smoking trucks and buses operating in California. Segments of the trucking industry argued that the snap-acceleration test used in the HDVIP was unreliable and incorrectly failed clean trucks. At least four lawsuits were filed to challenge the J1243 procedure; all of the decisions to date have upheld use of the test.

On October 15, 1993 the ARB temporarily suspended enforcement of the HDVIP and redirected the staff to work on reformulated fuels issues. Around the same time, the State Legislature enacted Assembly Bill (AB) 584 (Stats. 1993, ch. 578, Cortese), which required that the test procedures used in the HDVIP "produce consistent and repeatable results" and stated that this requirement is satisfied by the adoption of the SAE J1667 test procedure that was then under development. AB 584 further required that the program produce "no false failures," or ensure that any false failures be remedied without penalty to the vehicle owner. The ARB postponed resumption of the HDVIP pending the completion of SAE J1667 and the development of mechanisms for complying with the AB 584 mandates. Since October 15, 1993, the staff has continued outreach enforcement of the HDVIP on a voluntary compliance basis. In 1996 the Legislature enacted AB 1460 (Stats. 1996, ch. 292, Morrissey), making limited additional changes to the statute authorizing the HDVIP. After a multi-year process by the SAE task group, which included an ARB representative as well as representatives of industry, academia and other governmental agencies, the final SAE J1667 was issued in February 1996. In developing the document, the SAE task group addressed the technical issues surrounding the smoke test procedures, equipment performance specifications, and test corrections for the effects of altitude and weather.

The existing PSIP regulations. The PSIP regulations require that the owners of California-based fleets having two or more heavy-duty diesel-powered vehicles must perform annual inspections for excessive smoke and for defective or tampered emission control system components. Vehicles failing the smoke test or other aspects of the inspection must be repaired and retested. The smoke test is to be conducted using the SAE J1243 procedures specified in the HDVIP. Fleet owners are required to maintain specified records regarding their periodic inspections and follow-up repairs.

The PSIP regulations were adopted following a December 1992 hearing, in response to Health and Safety Code section 43701(a), enacted in 1990 by SB 2330 (Stats. 1990, ch. 1453, Killea). The regulations were originally scheduled to become operative in January 1995, with a 15-month phase-in period. In 1995 the Board amended the regulations to postpone the operative date until January 1, 1996, with the first 25 percent of an operator's fleet having to be tested by July 1, 1996. The Board enacted this postponement so that fleet operators could defer purchase of smokemeters until SAE's development of SAE J1667 was completed. Due to continued delays in the completion of SAE J1667, the ARB advised fleet operators in March 1996 that it would administer the PSIP as a voluntary program pending its adoption of the SAE J1667 procedure.

The proposed amendments. The staff is proposing the following amendments to implement the requirements of AB 584 and AB 1460, and to improve the regulations:

(1) Designate SAE J1667 "Snap-Acceleration Smoke Test Procedure for Heavy-Duty Diesel Powered Vehicles," as issued February 1996, as the test procedure for determining smoke opacity under the HDVIP and the PSIP.

(2) Maintain the existing snap-acceleration opacity standards of 55 percent for pre-1991 model-year heavy-duty diesel engines and 40 percent for 1991 and subsequent model-year heavy-duty diesel-powered engines, without reference to the engines' federal peak smoke certification level. These standards reflect data on maximum emissions from vehicles in good operating condition, gathered in the ARB's recently completed 71-vehicle Truck Repair Study, and include a safety margin to account for variability in smoke measurement. On average, an SAE J1667 type smokemeter reads about 5 to 10 opacity points less for mechanical and electronic engines, respectively, compared to an SAE J1243 type meter.

(3) Establish a mechanism under which owners of pre-1991 model-year heavy-duty diesel-powered engines that have roadside test snap-acceleration opacity levels that exceed 55 percent but do not exceed 69 percent are initially issued a Notice of Violation (NOV) in lieu of a citation. If, within 45 days, the owner demonstrates that he or she has made repairs which bring the vehicle into compliance with the 55 percent opacity standard, there will be no monetary penalty. If a demonstration of correction is not submitted within the 45-day period, a citation would be issued. The NOV mechanism would not apply where a previous NOV or citation had been issued for the vehicle in the preceding 12 months.

(4) Retain exemptions to allow technologically less stringent standards for specific engine families based on data submitted by the engine manufacturers, and "grandfather-in" exemptions of engine families issued under the preexisting HDVIP.

(5) Require explicitly that a demonstration of correction for a vehicle failing a roadside smoke test or visual inspection must include evidence that the vehicle has passed a post-repair test or inspection of the pertinent components.

(6) Institute a new 15-month phase-in schedule for the PSIP, starting July 1, 1998.

(7) Allow the SAE J1243 type smokemeter to be used in PSIP testing at facilities that are not equipped with an SAE J1667 type smokemeter, until July 1, 1999.

(8) Exempt the newest four model years of heavy-duty engines from the PSIP requirements (vehicles equipped with these engines would remain subject to roadside inspections under the HDVIP).

(9) Make various other changes to generally improve the regulations and to make them clearer and more readable.

(10) Define excessive smoke as smoke opacity exceeding the applicable opacity standard.

The administrative hearing process for challenging citations will be retained; the staff plans to propose various amendments to the administrative hearing regulations to be considered by the Board in the spring of 1998.

AVAILABILITY OF DOCUMENTS AND CONTACT PERSON

The Board staff has prepared a Staff Report which includes the initial statement of reasons for the proposed action and a summary of environmental impacts of the proposal. Copies of the Staff Report, the Technical Support Document, and the full text of the proposed regulatory language may be obtained from the Public Information Office, Air Resources Board, 2020 L Street, Sacramento, California 95814, (916) 322-2990. The Board staff has compiled a record which includes all information upon which the proposal is based. This material is available for inspection upon request to the contact persons identified below. The ARB has determined that it is not feasible to draft the regulations in plain English due to the technical nature of the regulations; however, a plain English summary of the regulation is available from the contact person named in the notice, and is also contained in the Staff Report: Initial Statement of Reasons for this regulatory action.

Further inquires regarding this matter should be directed to Mr. Ramon Cabrera or Mr. Robert Ianni of the Heavy Duty Diesel Branch in the ARB's Mobile Source Operations Division, at (626) 450-6177 and (916) 322-0845 respectively.

COSTS TO PUBLIC AGENCIES AND TO BUSINESSES AND PERSONS AFFECTED

The determinations of the Board's Executive Officer concerning the costs or savings necessarily incurred in reasonable compliance with the proposed regulatory action are presented below. An assessment of the economic impacts of the proposed regulatory action can be found in the Staff Report. Although the ARB has not yet resumed active enforcement of the HDVIP and the PSIP, the regulatory requirements have not been repealed and remain part of the California Code of Regulations. Accordingly, the analyses of the impacts of the proposed amendments set forth below are based on a comparison with the existing regulatory requirements, rather than a comparison to a situation where no heavy-duty inspection programs exist.

In preparing the regulatory proposal, the staff has considered the potential economic impacts on California business enterprises ar private individuals. Any business involved in the operation and service of heavy-duty diesel vehi es can potentially be affected by the proposed amendments. Also affected are businesses which manufacture the test equipment. All heavy-duty diesel trucks and buses operating on California roads, whether they are operated by an intrastate, interstate or international owner, are subject to the HDVIP. According to the ARB's MVE17G model, an estimated 570,561 and 777,214 heavy-duty diesel vehicles will be operating in California in 1999 and 2010 respectively. Approximately 81 percent of these vehicles — or an estimated 462,164 in 1999 and 629,543 in 2010 — will be registered in California. Of these California-registered vehicles, 63.1 percent will operate in fleets of two or more, and thus will also be subject to the requirements of the PSIP. These estimates compute to an estimated 291,625 vehicles in about 9,200 fleets subject to the PSIP in 1999, and an estimated 397,242 vehicles in about 12,600 fleets subject to the PSIP in 2010.

The proposed amendments do not change the basic PSIP requirement that fleet owners conduct annual smoke tests and inspections. The two significant proposed changes to the PSIP that could affect the costs of businesses are: (1) changing the smoke opacity test procedure from SAE J1243 to SAE J1667, and (2) exempting heavy-duty vehicles powered by 1994 and subsequent model-year engines until those engines are more than four model years old. The cost of SAE J1667 type smokemeters are, on average, about the same as the cost of SAE J1243 type smokemeters. Further, the steps taken to conduct an SAE J1667 test are similar to those associated with an SAE J1243 test. Accordingly, the change in the test procedure is expected to have no significant impacts on the costs of labor, the cost for smaller fleets to pay a separate entity for conducting the periodic tests, and, in most cases, the cost of smokemeters.

The one instance where the proposed change to the designated test procedure could have an adverse impact on fleet testing costs involves firms that have already acquired an SAE J1243 type smokemeter and will need to replace it with an SAE J1667 type smokemeter. There are several factors that suggest that the overall costs associated with replacing SAE J1243 type smokemeters will be minimal. First, it appears that relatively few fleet operators acquired SAE J1243 type smokemeters in anticipation of implementation of the PSIP. The ARB amended the regulations to delay implementation of the PSIP from January 1995 to January 1996 so that fleet operators would not have to buy SAE J1243 type smokemeters that would soon be outmoded. Second, two manufacturers of more expensive smokemeters have substantially lower prices for replacing or updating SAE J1243 type instruments (in one case, the upgrade is only $200). Third, the proposed regulations include a grandfather clause that allows, until July 1, 1999, PSIP testing with an SAE J1243 type meter at a facility that does not have an SAE J1667 type meter. By July 1999, fleets that had purchased SAE J1243 type smokemeters several years ago would be approaching the date the meters would need to be replaced in any case, since the estimated useful life of such smokemeters is 5-10 years.

With regard to the exemption for new engines during the first four model years, staff estimates that 26 percent of the diesel engines in covered fleets will at any one time be no more than four model years old. Thus the exemption is expected to reduce fleet administrative costs by an average of 26 percent, although only those fleets with the newer engines will be affected. Overall, this reduction in cost would be expected to offset any additional costs resulting from a need to replace SAE J1243 type smokemeters.

The remaining costs incurred by owners of heavy-duty vehicles in complying with the HDVIP and the PSIP consist of: (a) repair costs for vehicles failing an HDVIP or PSIP test, (b) increased costs for improved maintenance conducted by owners in order to avoid HDVIP or PSIP failures, (c) the lost opportunity cost of time spent undergoing HDVIP inspections, and (d) the savings from the reduced fuel costs that result from repairs and improved maintenance. Staff estimates that, overall, the amendments will result in a very small cost savings for these categories, due to the slightly reduced failure rate under the new test procedure.

For the above reasons, the proposed amendments are not expected to have a significant adverse economic impact on large or small businesses, including the ability of California businesses to compete with businesses in other states, or on directly affected private persons.

In accordance with Government Code section 11346.3, the Executive Officer has determined that the proposed regulatory action should have no significant effect on the creation or elimination of jobs within the State of California, the creation of new businesses or elimination of existing businesses within California, or the expansion of businesses currently doing business within California. An assessment of the economic impacts of the proposed regulatory action can be found in the Staff Report.

The Executive Officer has also determined, pursuant to Government Code section 11346.5(a)(3)(B), that the proposed regulatory action will affect small business.

The Executive Officer has determined that the proposed regulatory action will not incur costs or savings, as defined in Government Code section 11346.5(a)(6), to any state agency or in federal funding to the state, costs or mandate to any local agency or school district whether or not reimbursable by the state pursuant to Part 7 (commencing with section 17501), Division 4, Title 2 of the Government Code, or other nondiscretionary savings to local agencies. A significant number of state and local agencies and school districts operate heavy-duty vehicles that are subject to the HDVIP and the PSIP. The cost analysis for businesses set forth above is equally applicable to these public entities.

Before taking action on the proposed regulatory action, the Board must determine that no alternative considered by the agency would be more effective in carrying out the purpose for which the action is proposed or would be as effective and less burdensome to affected private persons than the proposed action.

SUBMITTAL OF COMMENTS

The public may present comments relating to this matter orally or in writing. To be considered by the Board, written submissions must be addressed and received by the Clerk of the Board, Air Resources Board, Post Office Box 2815, Sacramento, California 95812, no later than 12:00 noon December 10, 1997, or received by the Clerk of the Board at the hearing.

The Board requests, but does not require, that 20 copies of any written statement be submitted and that all written statements be filed at least 10 days prior to the hearing. The Board encourages members of the public to bring to the attention of staff in advance of the hearing any suggestions for modification of the proposed regulatory action.

STATUTORY AUTHORITY AND HEARING PROCEDURES

This regulatory action is proposed under the authority granted in sections 39600, 39601, 43013, 43701(a), and 44011.6, Health and Safety Code. This regulatory action is proposed to implement, interpret, and make specific sections 39002, 39003, 39010, 39033, 43000, 43013, 43018, 43701(a), and 44011.6, Health and Safety Code, and sections 305, 505 and 2813, Vehicle Code.

The public hearing will be conducted in accordance with the California Administrative Procedure Act, Title 2, Division 3, Part 1, Chapter 3.5 (commencing with section 11340) of the Government Code.

Following the public hearing, the Board may adopt the regulatory language as originally proposed, or with nonsubstantial or grammatical modifications. The Board may also adopt the proposed regulatory language with other modifications if the text as modified is sufficiently related to the originally proposed text that the public was adequately placed on notice that the regulatory language as modified could result from the proposed regulatory action; in such event the full regulatory text, with the modifications clearly indicated, will be made available to the public, for written comment, at least 15 days before it is adopted. The public may request a copy of the modified regulatory text from the Public Information Office, Air Resources Board, 2020 L Street, Sacramento, California 95814, (916) 322-2990.

CALIFORNIA AIR RESOURCES BOARD

Michael W. Scheible

for Michael P. Kenny
Executive Officer

Date: October 14, 1997

State of California
California Environmental Protection Agency

AIR RESOURCES BOARD

STAFF REPORT: INITIAL STATEMENT OF REASONS FOR PROPOSED RULEMAKING

PUBLIC HEARING TO CONSIDER PROPOSED AMENDMENTS TO THE CALIFORNIA REGULATIONS GOVERNING THE HEAVY-DUTY VEHICLE INSPECTION PROGRAM (HDVIP) AND THE PERIODIC SMOKE INSPECTION PROGRAM (PSIP)

October 1997

Prepared by:

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EXECUTIVE SUMMARY

Heavy-duty vehicles account for approximately 30 percent of the oxides of nitrogen (NOx) and 65 percent of the particulate matter (PM) emissions from the entire on-road fleet, despite the fact that these vehicles comprise only 2 percent of the California on-road vehicle fleet. To meet legislative mandates to reduce excess smoke emissions from in-use heavy duty diesel powered vehicles, the Air Resources Board (ARB or Board) staff is proposing amendments to the regulations governing the operation and enforcement of the Heavy-Duty Vehicle Inspection Program (HDVIP or the "roadside" program) and the Periodic Smoke Inspection Program (PSIP or the "fleet" program).

The existing roadside program was adopted in November 1990 in response to SB 1997 (stat. 1988, ch. 1544, Presley), and enforced from 1991 to 1993. It was suspended in October 1993, when the Board redirected staff to investigate reformulated fuels issues. The Board adopted the fleet program regulations in December 1992, but it had not yet been enforced. Both programs are currently being administered on a voluntary basis. Enforcement of these programs will resume when the staff's proposed regulatory amendments become effective.

Under the roadside program, heavy-duty diesel vehicles (including intrastate, interstate, and international vehicles) are tested for excessive smoke emissions and inspected for tampering at various field locations. The owners of vehicles failing prescribed test procedures are issued citations which require the prompt repair and carry civil penalties ranging from $300 to $1800 per violation. Failure to clear citations can result in vehicles being removed from service. Vehicle owners may appeal citations through the ARB's administrative hearing program.

The fleet program requires owners of two or more heavy-duty vehicles to perform an annual inspection of their diesel vehicles for excessive smoke emissions. This uses the same smoke test procedure as the roadside program.

The trucking industry has argued that the originally-specified snap-acceleration test using the "SAE J1243" type smokemeters can be unreliable and can fail "clean" trucks, although this test has been upheld by the California courts. To address this issue, the Legislature enacted AB 584 in 1993. This legislation requires that the smoke test procedure used must produce "consistent and repeatable" results and that the standards and test procedures result in no false failures unless they are remedied without penalty to the vehicle owner.

From 1992 through 1996, a Society of Automotive Engineers (SAE) committee (including ARB staff, the trucking industry, engine manufacturers, smokemeter manufacturers, et al) worked to develop a smoke test procedure specifically for inspection programs. The resulting procedure, SAE J1667, was adopted unanimously by this committee in 1996. AB 584 specifically states that SAE J1667 fulfills the requirements that the test procedure be consistent and repeatable.

In 1996 and 1997, the staff conducted two studies, the Random Truck Opacity Survey and the Truck Repair Study, that provide the technical basis for staff's proposed amendments. These studies are discussed in detail in the Staff Report and its companion Technical Support Document.

The staff's proposal includes the following amendments to the existing regulations:

(1) Designate SAE J1667 as the test procedure for determining smoke opacity.

(2) Maintain the existing snap-acceleration opacity standards of 55 percent for pre-1991 model years and 40 percent for 1991 and newer model year heavy-duty diesel powered engines, as measured by the new test procedure.

(3) Establish a mechanism under which owners of pre-1991 model year heavy-duty diesel engines that have roadside snap-acceleration opacity levels exceeding 55 percent but not exceeding 69 percent are initially issued a Notice of Violation (NOV). An owner has 45 days without penalty to bring the vehicle into compliance with the 55 percent standard before a citation is issued. The NOV mechanism would not apply where a previous NOV or citation had been issued for the vehicle in the preceding 12 months.

(4) Retain exemptions to allow for less stringent standards for specific engine families based on data submitted by the engine manufacturers, and "grandfather-in" exemptions of engine families issued under the preexisting HDVIP regulations.

(5) Institute a new 15 month phase-in schedule for the PSIP, starting July 1, 1998.

(6) Allow the previous type of smokemeter to be used in PSIP testing at facilities that are not equipped with an SAE J1667 type smokemeter, until July 1, 1999.

(7) Exempt the newest four model years of heavy-duty engines from the PSIP requirements under a four year "rolling exemption" process.

Compared to having no heavy-duty inspection programs, the roadside and fleet programs with the proposed amendments are expected to achieve the following emission reductions of reactive organic gases (ROG), NOx and PM:

	ROG	NO_x	PM-10
1999	6.37	12.24	5.24
2010	5.30	14.03	3.19

Although the numerical opacity standards in the proposal are identical to the preexisting standards, they are somewhat less stringent in the proposal because the SAE J1667 smokemeter reads about 5 to 10 opacity points less than the prior SAE J1243 type smokemeter. The staff is recommending these standards because they are necessary to assure that the reinstated programs will comply with the AB 584 restrictions regarding an absence of false failures. The Staff Report compares the estimated emission reductions from the proposal with the somewhat larger reductions that would be estimated from the original regulations.

Diesel fuel consumption will be reduced by approximately 16.7 and 19.2 million gallons annually in 1999 and 2010, respectively. This represents a savings over the 12-year period of approximately 250 million gallons of fuel or over $212 million (at current fuel prices.)

I. INTRODUCTION

In this rulemaking, the Air Resources Board (ARB) staff is proposing amendments to the regulations governing the operation of the Heavy-Duty Vehicle Inspection Program (HDVIP or the "roadside" program) and the Periodic Smoke Inspection Program (PSIP or the "fleet" program). The primary objective of these enforcement programs is to reduce the excessive smoke emissions from mal-maintained and tampered heavy-duty diesel powered vehicles operating in California. The proposed amendments are designed to assure that these statutorily mandated programs can be effectively and vigorously administered in accordance with recent legislative requirements.

The regulations for both of the programs are currently in place in the California Code of Regulations. They impose limits on the opacity of smoke from diesel engines when measured in accordance with a "snap-acceleration" stationary vehicle test procedure that uses an electronic smokemeter meeting the requirements of the Society of Automotive Engineers (SAE) SAE J1243 procedure. Opacity means the percentage of light obstructed from passage through an exhaust smoke plume. The HDVIP involves roadside inspections by ARB inspectors, who are to issue citations to trucks and buses that exceed the smoke opacity standards. In the PSIP, owners of fleets of two or more heavy-duty vehicles are to annually conduct inspections and smoke tests and to make any repairs necessary for the vehicles to meet the opacity standards.

The HDVIP regulations became operative on November 21, 1991. The program was actively enforced until October 15, 1993 when the ARB temporarily suspended enforcement of the program and redirected the staff to work on reformulated fuels issues. Around the same time, the legislature enacted a new law which included a requirement that the test procedures used in the HDVIP "produce consistent and repeatable results," stating that this requirement is satisfied by the adoption of the new SAE J1667 test procedure that was then under development. The ARB postponed resumption of the HDVIP pending the completion of SAE J1667 and the development of mechanisms for complying with the legislative mandates. The ARB also refrained from immediately enforcing the PSIP at the January 1996 implementation date. In the interim, the ARB staff has been administering the programs on a voluntary outreach basis.

The staff's proposed regulatory amendments are designed to comply with the mandates of the new 1993 law, Assembly Bill (AB) 584 (Stats. 1993, ch. 570, Cortese). The amendments provide that smoke opacity is to be determined using SAE J1667 as it was finally adopted by SAE in 1996. The staff conducted two major studies in 1996-1997 to identify appropriate opacity standards for use with the revised test procedure. The proposed opacity standards and other mechanisms are designed to satisfy the AB 584 requirement that the programs be designed to ensure that vehicles in good operating condition and adjusted to the manufacturers' specifications will not fail the standards, and that false failures be eliminated or remedied without penalty to the owner. The amendments also make a variety of other improvements to the programs.

With adoption of the proposed amendments, the ARB will be able to resume enforcement of the roadside program and fully implement the fleet self-inspection program. These programs will bring substantial benefits, both by reducing in the number of diesel powered trucks and buses with excessive smoke and reducing the contribution those vehicles make to overall poor air quality.

II. BACKGROUND

A. Emissions from Heavy-Duty Diesel Vehicles

Emissions from heavy-duty diesel trucks and buses have a major impact on California's air quality. Heavy-duty vehicles account for approximately 30 percent of the oxides of nitrogen (NOx) and 65 percent of the particulate matter (PM) exhaust emissions from the entire on-road fleet, even though these vehicles only comprise approximately 2 percent of the entire California on-road vehicle fleet and 4 percent of the vehicle miles traveled. The NOx emissions, when combined with various hydrocarbon (HC) emissions and sunlight, form ozone—commonly referred to as "smog." Consequently, the NOx emissions, and to a lesser degree the HC emissions from heavy-duty trucks and buses significantly contribute to violations of the state and federal ambient air quality standards for ozone. Diesel exhaust particulate emissions, commonly referred to as "soot," are fine particles designated as PM-10, most of which are designated as PM-2.5.[1] NOx emissions can also contribute to PM pollution through the formation of nitrates. These particulate emissions contribute to violations of the state and federal ambient air quality standards for particulate matter and contribute to reduced visibility. The HDVIP and PSIP are designed to reduce excessive in-use emissions of these pollutants that are primarily the result of improper vehicle maintenance practices and tampering.

Despite recent improvements in air quality, violation of the national ambient air quality standards for both ozone and particulate matter continue to occur on a regular basis in the State and especially in the South Coast Air Basin. During 1996, the federal and the more stringent State ozone standards were violated in the South Coast Air Basin on 90 and 152 days, respectively. Ozone and particulate matter pollution are of great concern because of their adverse effects on human health. Ozone is a known respiratory irritant that harms lung tissue and reduces breathing capacity. Its effects are strongest in sensitive individuals such as asthmatics, the elderly, and children. Based on recent epidemiological studies,[2] particulate matter pollution has been consistently related to premature mortalities. According to a recent Natural Resource Defense Council study,[3] particulate matter pollution causes between 8,600 and 19,400 premature deaths in

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1 PM-10 is particulate matter less than or equal to 10 microns in size, and PM-2.5 is particulate matter less than or equal to 2.5 microns in size. Studies show that diesel exhaust is primarily PM-2.5.

2 Dockery, Douglas W. et al. "An Association Between Air Pollution and Mortality in Six U.S. Cities." New England Journal of Medicine, Vol. 329, No. 24, pp. 1753-9.

3 Shprentz, Deborah Sheiman, et al., Natural Resource Defense Council. Breath-Taking: Premature Mortality due to Particulate Air Pollution in 239 American Cities May 1996.

California every year. In response to evidence relating ozone and particulate matter pollution to these and other health effects, the United States Environmental Protection Agency (U.S. EPA) recently tightened both the Federal ozone and particulate standards.

Constituents of diesel exhaust have been identified as toxic air contaminants under the ARB's Toxic Air Contaminant Program, and whole diesel exhaust is currently under review for identification. The International Agency for Research on Cancer has identified diesel exhaust as a probable human carcinogen.[4] Diesel exhaust was identified in 1990 under California's Proposition 65 as a chemical known to cause cancer.

Other environmental impacts of diesel exhaust include visibility degradation, acid deposition, and vegetation/forestry damage. Emissions from diesel vehicles contribute to the losses caused by air pollution to California agriculture. These losses are estimated to exceed $300 million per year in direct crop yield losses and $1 billion per year when processing and distribution effects are included, according to studies conducted by the ARB and the University of California. Also, excessive exhaust emissions (black smoke) from on-road heavy-duty vehicles continue to be the number one target of public complaints regarding air pollution.

B. Establishment of the Heavy-Duty Vehicle Inspection Programs

<u>Heavy-Duty Vehicle Inspection Program</u>

In 1988, the Legislature enacted Senate Bill 1997 (Stats. 1988 ch. 1544, Presley), directing the ARB in cooperation with the California Highway Patrol (CHP) to design and implement an in-use roadside smoke enforcement program for heavy-duty vehicles. The regulations governing the resulting program, the HDVIP, were adopted by the ARB following a November 8, 1990 hearing and became operative on November 21, 1991.

Under this program, heavy-duty diesel powered trucks and buses are tested for excessive smoke emissions, and heavy-duty diesel and gasoline powered trucks and buses are inspected for tampering. The program is designed as a roadside program, as opposed to the registration-based programs used in other states, in order to inspect all heavy-duty vehicles traveling on California's roads. Based on ARB studies, at any given time, approximately 28 percent of the miles driven by on-road heavy-duty vehicles are driven by out-of-state or out-of-country vehicles. Furthermore, with the promulgation of NAFTA, the presence of out-of-country vehicles traveling on California's roads is likely to increase. Intrastate, interstate, and international heavy-duty vehicles are tested statewide by ARB inspectors at CHP inspection facilities and weigh stations, and at random roadside locations.

In the original HDVIP regulations, all 1974 and subsequent model-year vehicles with federal peak smoke engine certification levels lower than 35 percent were subject to a 40 percent opacity

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4 <u>The Toxic Air Contaminant Identification Process: Diesel Exhaust.</u> California Environmental Protection Agency, Air Resources Board, June 1994.

standard; all others were subject to the 55 percent opacity standard. However, a provision stated that the only vehicles subject to a civil penalty for failing the 40 percent standard during the first year of the program were 1991 and subsequent model-year vehicles, and this provision was extended by the Executive Officer. In effect, all pre-1991 model-year vehicles were subject to a 55 percent standard. As noted above, the opacity of smoke from diesel engines was measured in accordance with a "snap-acceleration" (previously referred to as "snap-idle") test procedure that used an electronic smokemeter meeting the requirements of the SAE J1243 procedure. The vehicles are also inspected for tampered or defective emission control system components. The owners of failing vehicles are issued citations which require the prompt repair of the vehicle and carry civil penalties ranging from $300 to $1800 per violation. Failure to clear citations can result in vehicles being removed from service by the CHP, at the request of the ARB. Vehicle owners may appeal citations through the ARB's administrative hearing program established in sections 60075.1 through 60075.47, Title 17, California Code of Regulations.

The HDVIP proved very effective during the November 1991 - October 1993 period when it was actively enforced. During this time, the number of vehicles failing to meet the standard was reduced from 34 percent to 21 percent, resulting in an estimated 38 percent reduction in the number of heavy-duty smoking trucks and buses operating in California.

Periodic Smoke Inspection Program

The PSIP was mandated by Senate Bill (SB) 2330 (Stats. 1990, ch. 1453, Killea) to promote self-inspection of fleet vehicles. Under the PSIP, California-based truck and bus fleets with two or more vehicles are required to conduct annual smoke opacity and tampering self-inspections for all of their vehicles. To ensure program compliance, the ARB staff is required to audit these fleets by reviewing their maintenance and inspection records and by testing a representative sample of vehicles. The PSIP has the additional benefit of including fleet vehicles that would normally not be subject to the HDVIP roadside enforcement operations (i.e., local service and delivery vehicles).

The regulations governing the PSIP were adopted following a December 1992 hearing and were originally scheduled to become effective on January 1, 1995. Because of delays in the completion of the SAE J1667 test procedure, the Board amended the regulations to postpone their effective date to January 1, 1996 where the first 25 percent of an operator's fleet having to be tested by July 1, 1996. In a March 1996 notice, the ARB staff advised fleet operators that the PSIP would be administered as a voluntary program pending adoption of the SAE J1667 procedure into the program's governing regulations.

Vehicle Inspection Programs in Other States

Presently, several states have enforcement programs for in-use heavy-duty diesel vehicles. Arizona was the first to implement such a program in 1970, and four other states have active programs in effect today. Other states have regulations in place but, to date, have not enforced their programs.

C. Enactment of Assembly Bill 584 and Related Developments

While the HDVIP has been effective in reducing emissions and the number of smoking vehicles in California, its snap-acceleration test has been the focus of controversy. The California Trucking Association (CTA) has asserted that the test can be unreliable and can incorrectly fail "clean" trucks. This debate has been on-going since the program's implementation in 1991. The legality of the HDVIP and its test procedure has been challenged in four lawsuits filed by CTA attorneys. In all cases, the test has been upheld by the California courts including two decisions from the Third District Court of Appeals that were left standing by the California Supreme Court. (The litigation over the HDVIP is described in Attachment E.)

However, as a result of this controversy and the proliferation of similar smoke enforcement programs in other states, the SAE formed a task group in 1992 to develop a recommended snap-acceleration smoke test procedure—SAE J1667—specifically designed for use in roadside inspections. This broad-based task group included representatives from the ARB, U.S. EPA, representatives from other states, engine manufacturers, the trucking industry (CTA and the American Trucking Association), and smokemeter manufacturers, as well as various academicians.

In response to testing concerns, in 1993, the Legislature enacted Assembly Bill 584, which was sponsored by the trucking industry. This legislation amended Health and Safety Code section 44011.6 to require that the smoke test procedure used in the HDVIP must yield consistent and repeatable test results and not result in "false failures." The pertinent portions of H&SC Section 44011.6 now provide as follows:

(c) Any smoke testing procedures or smoke measuring equipment, including any meter that measures smoke opacity or density and any recorder that stores or records smoke opacity or density measurements, used to test for compliance with this section and regulations adopted pursuant to this section, shall produce consistent and repeatable results. The requirements of this subdivision shall be satisfied by the adoption of Society of Automotive Engineers recommended practice J1667, "Snap-Acceleration Smoke Test Procedures for Heavy-Duty Diesel powered Vehicles."

(d)(1) The smoke test standards and procedures adopted and implemented pursuant to this section shall be designed to ensure that no engine will fail the smoke test standards and procedures when the engine is in good operating condition and is adjusted to the manufacturer's specifications.

(2) In implementing this section, the state board shall adopt regulations that ensure that there will be no false failures or that ensure that the state board will remedy any false failures without any penalty to the vehicle owner.

In 1996, the Legislature enacted additional limited changes to the HDVIP provisions of Health and Safety Code section 44011.6, (Stats. 1996 ch. 292 (AB 1460, Morrissey).)

The development and adoption of SAE J1667 proved to be a lengthy process. The group identified three primary technical issues. The first two concern the effect that a smokemeter's response time has on measured smoke values, and the third concerns the effect that ambient conditions can have on smoke emissions. (These issues are discussed in Section IV.A. below.) Ultimately, the procedure was adopted unanimously, and was issued in February 1996.

Subsequent to the SAE's adoption of the J1667 test procedure, the ARB staff, in consultation with the regulated industries and other interested parties, conducted two studies to assess the effectiveness of the J1667 test procedure and to provide the technical basis for the selection of opacity standards and other mechanisms that meet the requirements of AB 584.

The first study was called the "Random Truck Opacity Survey," or RTOS. As the name implies, heavy-duty diesel vehicles were randomly sampled from the in-use California fleet and tested using the SAE J1667 procedure. The purpose was to determine the distribution of the in-use smoke opacity of the fleet of heavy-duty diesel trucks currently operating in California. The RTOS served to quantify the extent of the smoky truck problem under a reinstated HDVIP. Between August and November 1996, SAE J1667 smoke test results were obtained for a usable sample of 1002 heavy-duty diesel vehicles. The study provided a detailed characterization of the smoke opacity distribution of heavy-duty diesel vehicles with engines from most model year groups of interest. (A more detailed analysis of the RTOS is contained in the Technical Support Document.)

The second study became known as the "Truck Repair Study," or TRS. It was conducted from December 1996 to July 1997, after the RTOS had been completed. As noted above, AB 584 required that the HDVIP be designed so that no engine in good operating condition and adjusted to the manufacturer's specifications will fail the smoke standard. The object of the TRS was to determine the appropriate opacity standards by procuring and repairing a sample of heavy-duty vehicles spanning a range of smoke opacities. The opacity of the vehicles after repairs would provide the basis for determining the appropriate opacity level that could be met by engines in good operating condition and correctly adjusted. The repairs were performed by dealerships and factory-authorized personnel, to help assure the competence of the mechanics. A requirement that each repaired vehicle be within manufacturer specifications after the repair helped assure that the vehicles were properly adjusted. All tests were conducted in conformance with SAE J1667.

In all, 71 trucks and buses were recruited for the TRS. The initial SAE J1667 opacity tests had shown that these vehicles' opacities were in the range of interest. Numerous engine makes and model years, with a wide range of snap acceleration test opacities, were included in the sample. The following table shows the *pre*-repair opacity range distribution for the 63 pre-1991 engines in the sample. (The *post*-repair opacity distribution is shown in Section IV.B.1.)

Table 1

Truck Repair Study
Pre-Repair Opacity Distribution
(63 Pre-1991 Model Year Heavy-Duty Engines)

Opacity Range	*Sample Percentage*
35 to 45	15.87
45 to 55	17.46
55 to 65	15.87
65 to 75	26.99
75 to 85	4.76
85+	19.05

In general, the TRS revealed that the HDVIP, employing the SAE J1667 test procedure, would be a very effective enforcement program capable of identifying vehicles with excessive smoke emissions without producing false failures. (A more detailed summary of the TRS is contained in the Technical Support Document.)

D. Public Process and Outreach

Throughout the development of the original HDVIP and continuing to the present, the staff has solicited the participation of industry. As required by Senate Bill 1997, the ARB organized an Ad-Hoc Technical Advisory Committee to help formulate an effective HDVIP program and presided over its meetings. Committee members include the CTA, the EMA, the South Coast Air Quality Management District, the Highway Carriers Association, the California Bus Association, the CHP, California Transit Association, heavy-duty diesel repair facilities, a fuel refiner, and others.

The staff consulted with interested parties on an on-going basis in the development and implementation of the Random Truck Opacity Study and the Truck Repair Study. The Ad-Hoc Technical Advisory Committee participated in the design of the TRS. Throughout the RTOS and the TRS, the staff held monthly meetings with the CTA and the EMA to discuss both their design and progress. In particular, EMA provided technical and monetary assistance in the two engineering studies.

As part of the rulemaking process, staff held a public workshop on September 11, 1997 to discuss a draft of the staff's proposal as well as a draft Technical Support Document. As a result of the industry's ongoing participation in the development of the HDVIP and PSIP amendments, only the CTA proposed a modification to the staff's proposal. The CTA maintained that the originally-proposed standards for pre-1991 model year engines were too stringent to guarantee compliance with AB 584. This issue is discussed in Sections IV.B.5. and IV.C. below. The staff has also maintained communication with other interested parties, including numerous environmental organizations, throughout the development of this proposal.

In order to successfully resume the HDVIP and the PSIP, the staff has undertaken an extensive outreach effort to educate the affected industry. The ARB staff routinely conducts compliance seminars at both private and public trucking and bus entities. To date, the staff has conducted hundreds of training seminars.

Since it is also important to educate the heavy-duty diesel repair industry, in 1992, the ARB established a partnership with selected California community colleges to develop a formal training curriculum. The California Council on Diesel Education and Technology (CCDET) curriculum is designed to train heavy-duty diesel engine service personnel how to properly test vehicles for smoke opacity and diagnose and repair vehicles with high smoke emissions. This program is formally called. Currently, there are four colleges participating in this program with nine additional colleges ready to join. Since the formation of CCDET in 1992, approximately 1000 heavy-duty diesel engine service personnel have been trained and certified under this program. This program is being updated to include training on the proposed changes to the HDVIP and PSIP, including the incorporation of the SAE J1667 procedure.

III. SUMMARY OF THE REGULATORY PROPOSAL

Staff recommends that the Board adopt the amendments to the HDVIP and PSIP regulations set forth in the Proposed Regulation Order in Attachment A. The proposed amendments are designed to assure compliance with AB 584 and to make a variety of other improvements developed from past experience with the programs. The significant proposed changes are summarized below and then discussed in the next Section. Attachment B provides a section-by-section explanation of all of the proposed amendments, including those intended to clarify existing regulatory provisions or to improve their readability.

(1) Designate the SAE J1667 "Snap Acceleration Smoke Test Procedure for Heavy-Duty Diesel Powered Vehicles," as issued February 1996, as the test procedure for determining smoke opacity under the HDVIP and PSIP.

(2) Maintain the existing snap-acceleration opacity standards of 55 percent for pre-1991 model year heavy-duty diesel powered engines and 40 percent for 1991 and newer model year heavy-duty diesel powered engines, without reference to the engines' federal peak smoke certification level. These standards reflect data on maximum emissions from vehicles in good operating condition and set to manufacturers' specifications, gathered from the ARB's recently completed 71

vehicle Truck Repair Study. These standards also include a significant safety margin to account for variability in smoke measurement.

(3) Establish a mechanism under which owners of pre-1991 model year heavy-duty diesel powered engines that have roadside snap-acceleration opacity levels exceeding 55 percent but not exceeding 69 percent are initially issued a Notice of Violation (NOV) in lieu of a citation. If, within 45 days, the owner demonstrates that he or she has made repairs that bring the vehicle into compliance with the 55 percent opacity standard, there will be no monetary penalty. If a demonstration of correction is not submitted within the 45-day period, a citation would be issued. The NOV mechanism would not apply where a previous NOV or citation had been issued for the vehicle in the preceding 12 months. Based on the initial experience with the NOV approach, the staff plans to report to the Board by the end of 1999 with its recommendation on whether the approach should be sunsetted.

A summary of the opacity standards described in (2) and (3) above is provided in the following table.

Table 2.

Smoke Opacity Standards and ARB Actions

Vehicles with Pre-1991 Model Year Engines		
Opacity Standard 55%		
Test Opacity	**ARB Action**	**Post-Repair Standard**
Higher than 70 %	*Issue Citation*	*<55 %*
Between 55 - 70%	*Issue Notice of Violation**	*<55 %*
Vehicles with 1991 and Newer Model Year Engines		
Opacity Standard 40%		
Test Opacity	**ARB Action**	**Post-Repair Standard**
Higher than 40 %	*Issue Citation*	*<40 %*

*Applicable only to first violation in 12-month period

(4) Retain exemptions to allow for technologically less stringent standards for specific engine families based on data submitted by the engine manufacturers and "grandfather-in" exemptions of engine families issued under the preexisting HDVIP regulations.

(5) Require explicitly that a demonstration of correction for a vehicle failing a roadside smoke test or visual inspection must include evidence that the vehicle has passed a post-repair test or inspection of the pertinent components.

(6) Institute a new 15 month phase-in schedule for the PSIP, starting July 1, 1998.

(7) Allow the SAE J1243 type smokemeter to be used in PSIP testing at facilities that are not equipped with an SAE J1667 type smokemeter, until July 1, 1999.

(8) Exempt the newest four model years of heavy-duty engines from the PSIP requirements. Vehicles equipped with these engines would remain subject to the roadside inspections under the HDVIP.

(9) Define "excessive smoke" as smoke opacity in excess of the opacity standards set forth in (2) and (3) above and summarized in Table 1 above.

(10) Retain the administrative hearing process for challenges to citations. The staff plans to propose various amendments to the administrative hearing regulations to be considered by the Board in the spring of 1998.

IV. DISCUSSION OF THE PROPOSED AMENDMENTS

A. Incorporation of the SAE J1667 Snap-Acceleration Test Procedure

The staff is proposing that the SAE J1667 "Snap-Acceleration Smoke Test Procedure for Heavy-Duty Diesel Powered Vehicles" be designated as the test procedure for determining smoke opacity. It is stated in AB 584 that the adoption of SAE J1667 satisfies the requirements that the smoke test procedure assures repeatable and consistent results.

The SAE J1667 snap-acceleration test procedure was designed to respond to three concerns about possible inconsistencies in different meters' measurements of snap-acceleration smoke emissions. The first two concerns involve the relationship between smokemeters' response times and the measured opacities. The third involves the effects of ambient test conditions on measured opacities. These three concerns are discussed in this section. (A more detailed discussion is contained in the Technical Support Document.)

1. <u>Meter Response Time Specifications</u>

Diesel engines with different technologies are likely to have significantly different snap-acceleration smoke opacity profiles. Some opacity profiles are sharply peaked while others are much broader. The different response times of smokemeters may significantly affect the opacities they report. For example, if an engine has a sharply-peaked opacity profile, a meter with a slower response time will measure a lower smoke value than a meter with a faster response time. To eliminate the effects of different response times, SAE J1667 requires that measurement response times be normalized to 0.5 second and suggests that a digital Bessel filter be used to achieve the prescribed response time. The ARB will use meters satisfying the meter specifications of SAE J1667 in the HDVIP and the PSIP.

2. <u>Attenuation of Irrelevant Snap-Acceleration "Peak" Opacities</u>

The second concern is closely related to the first. Experience has shown that engines whose snap-acceleration opacity profiles are highly peaked and of short duration may be in good operating condition, even though the peak opacities of their profiles are high. Meters satisfying the specifications of SAE J1667 have 0.5 second response times, which sufficiently attenuate the irrelevant high peak opacities of sharply-peaked profiles.

3. <u>Corrections for Ambient Test Conditions</u>

Because the opacity of smoke emissions is an indication of the completeness of combustion, any ambient condition that affects an engine's air/fuel ratio can be expected to affect the opacity of its smoke, whether or not the engine is within manufacturer's specifications. When a vehicle is tested at higher elevations, the lower oxygen content of the thinner air decreases the completeness of combustion and increases the opacity of smoke emissions. The emissions of mechanical engines that do not have effective feedback systems controlling the air/fuel ratio are especially affected. Measured opacities must be corrected to standard ambient conditions to account for the effects of different ambient test conditions before being compared to standards. The SAE J1667 procedure incorporates an algorithm for making these corrections and the ARB will use this algorithm when conducting inspections.

B. Selection of Proposed Opacity Standards and Other Mechanisms to Avoid False Failures

Apart from the designation of the test method, AB 584 requires the ARB to satisfy the following two requirements in adopting HDVIP regulations and standards:

- The standards and test procedures are to be designed to ensure that no vehicle in "good operating condition" and "adjusted to the manufacturer's specifications" will fail, and
- The regulations must ensure that there will be no false failures or ensure that the ARB will remedy any false failures without penalty to the vehicle owner.

The first criterion has been addressed through use of the data generated in the Truck Repair Study. The smoke opacities of the vehicles after they were repaired to the manufacturers' specifications by factory authorized repair facilities were compiled to identify opacity standards that will be met by vehicles in good operating condition and correctly adjusted. Making appropriate additional allowances in the standards for variability in smoke measurements in the derivation of standards will also help prevent the occurrence of false failures.

1. Using the Post-Repair Smoke Opacity Levels Measured in the Truck Repair Study

The following table shows the *post*-repair opacity distribution for the 63 pre-1991 engines in the TRS:

Table 3

Truck Repair Study Post-Repair Opacity Distribution (63 Pre-1991 Model Year Heavy-Duty Engines)

Opacity Range	*Sample Percentage*
5 to 10	6.3
10 to 15	23.8
15 to 20	17.5
20 to 25	15.9
25 to 30	20.6
30 to 35	6.3
35 to 40	4.8
40+	4.8*

*This percentage represents one vehicle that did not undergo complete repairs (at owner's request.)

As can be seen by this distribution, over 80 percent of the engines were repaired to smoke levels below 30 opacity points. The highest post-repair opacity of a fully repaired pre-1991 engine in the TRS was 38.7 percent, which suggests that the standard should be 39 percent or higher. However, one engine received repairs that only brought the opacity value down to 47 percent; the mechanic suggested there may have been injector problems, but the owner was unwilling to wait for further diagnostics and potential additional repairs. Under a very conservative analysis, one could consider the opacity value for this engine to be the highest post-repair value for an engine in "good working order" because the injector problem remained unconfirmed. This analysis suggests that a more conservative, less stringent opacity standard than 39 percent might be appropriate.

For the eight 1991 and newer engines in the TRS, the highest post-repair opacity was 30.6 percent, suggesting that the standard should be 31 percent or higher. However, the sample of 1991 and newer engines in the TRS was small, and the quality of some repairs may not have been satisfactory, suggesting that a more stringent standard may be appropriate.

2. Allowance for Variability in Measuring Opacity

There are three sources of variability when the opacity of an engine's exhaust is measured using the SAE J1667 procedures: (1) drift of the engine's opacities over time, (2) short-term variability of repeated measurements of the engine's opacity by the same model of smokemeter, and (3) variability of the measurements of opacities of the same SAE J1667 test by different models of meters satisfying the SAE J1667 smokemeter specifications.

The issue of engine variability over time, often referred to as engine drift, is complex since this variability is a function of the time period over which the engine's opacities are repeatedly measured. Engines tend to become more variable with use and over time because of deterioration of parts and malmaintenance. A principal consideration in allowing for measurement variability is that variability associated with such changes in the engine should not be accounted for in the standard setting process, because the causes are correctable malperformances.

The second source of variability is the short-term cycle-to-cycle variability of individual engines' opacities measured by the same smokemeter. The variability of the smokemeter's measurements of these opacities also contributes to this source. All other factors are assumed to be held constant. Data on this source of variability must be obtained from engines in good working order. The data are obtained from observed differences between the opacities of two tests performed within a relatively short time period during which in-use deterioration is very unlikely to have occurred.

An engine's cycle-to-cycle variability was estimated from pairs of post-repair smoke opacity tests in the TRS. The first test was performed by dealership staff and the second test by the ARB field staff. These pairs of measurements were performed on the same day or on successive days, but more importantly, the engine was presumably operated very little between the two measurements. Data from pairs of tests are available for 25 of the 71 engines in the TRS sample. Differences of these paired measurements had a mean of 0.20 percent and a standard deviation of 1.92 percent.

The third type of variability occurs when opacity is measured with different smokemeters that satisfy the SAE J1667 smokemeter specifications. The extent of this type of variability was estimated from the results of a study of the correlation of five such smokemeters conducted in April 1996. Pairs of smokemeters simultaneously measured the same smoke plumes of six representative engines. The standard deviation of the paired differences of these smokemeters was 2.4 percent. The statistical independence of these two sources of variability is very plausible, because they were measured in completely independent experiments. The standard deviation of the combined independent sources of variability is 3.1 percent

An allowance for the combined measurement variability of the second and third sources is computed as a one-sided upper tolerance interval for their sum. The computed tolerance interval covers 95 percent of the population and has a confidence level of 95 percent. Their coverage of a high proportion of the population at a high confidence level makes such intervals well-suited to estimating allowances for variability in situations where the number of false failures is to be minimized. Assuming that the two sources of variation are normally distributed, the computed tolerance interval is an allowance for variability of 7.2 percent, which is conservatively increased to 8 percent.

3. Computing Standards from the Post-Repair Opacity Levels and an Allowance for Variability

Adding the 8 percent allowance for variability to the baseline maximum post-repair opacities of 47 percent for pre-1991 engines and 30.8 percent for 1991 and newer engines yields equivalent post-repair standards of 55 percent and 40 percent, respectively. These values are numerically identical to the previous HDVIP standards. However, for both older and newer engines, the maximum post-repair opacity values may not reflect complete or correct repairs. It appears possible and indeed likely that a larger sample of data on complete repairs could result in lower standards for both categories. The feasibility of significantly lower standards for 1991 and newer engines appears to be a distinct possibility.

4. Comparison to the Original HDVIP Standards and Test Procedures

Although the current standards for opacities measured with SAE J1243 smokemeters and the proposed standards for opacities measured with SAE J1667 smokemeters have the same numerical values, the proposed standards are in fact less stringent for almost all engines. On average, an SAE J1667 type smokemeter reads about 5 to 10 opacity points less for mechanical and electronic engines, respectively, compared to an SAE J1243 type smokemeter. Accordingly, the proposed standards are somewhat less stringent than the standards and test procedures now specified in the HDVIP regulations.

The reduced stringency of the proposed standards is due to the 0.5 second response time requirement for SAE J1667 smokemeters, which attenuates the peak opacities of sharply-peaked smoke profiles. In analyzing the differences between opacities of the same engines measured by SAE J1243 and SAE J1667 smokemeters a few minutes apart the SAE J1667 opacities were almost always smaller. For engines with electronically controlled fuel systems, only 1 percent of the SAE J1667 opacities were larger. For engines with mechanically controlled fuel systems, only 10 percent of the opacities were more than 3 opacity points or larger.

The fact that fewer vehicles will be failed under the new SAE J1667 procedure than would be failed under the SAE J1243 procedure with numerically identical opacity standards will provide an additional safeguard against possible false failures.

5. Standards for Pre-1991 Engines

The CTA has expressed concern that a possibility exists for false failures to occur if the proposed 55 percent standard is adopted for pre-1991 engines. They have indicated that an alternative standard of 70 percent would provide a stronger assurance that false failures will not occur, that the HDVIP would be consistent with the mandates of AB 584, and that enforcement of this standard would achieve the goals of the HDVIP and PSIP. CTA further maintains that most of the programs' benefit can be achieved by simply targeting gross polluting trucks—a position consistent with the belief that in-use enforcement programs tailored towards gross polluters tend to be very cost effective.

However, the data generated in the Truck Repair Study demonstrate that a 55 percent opacity standard for pre-1991 model-year engines is both prudent and consistent with the mandates of AB 584. However, to provide a distinction between gross polluters and those with lower but still objectionable and unnecessary smoke emissions, the staff is proposing the NOV mechanism discussed in Section IV.C. below.

6. Standards for 1991 and Newer Engines

The technological feasibility of the staff's proposed 40 percent snap-acceleration opacity standard for newer technology engines (1991 and newer model year engines) is not being disputed. Prior to 1991, heavy-duty diesel truck and bus engines had to meet a particulate matter standard of 0.60 or greater gram per brake-horse-power hour (g/bhp-hr). The engine certification process is very rigorous, and engines are required to be tested on an engine dynamometer. Since 1991, California urban bus engines must be certified to a new engine particulate matter standard of 0.10 (or less) g/bhp-hr. On-road heavy-duty diesel engines (including engines used in non-urban buses), for both California and federal certification in model years 1991 through 1993, had to meet a 0.25 g/bhp-hr PM standard. The same engines for the 1994 and subsequent model years have to meet a California and federal standard of 0.10 g/bhp-hr. Such low particulate emission standards ensures that these engines, if properly maintained, should have extremely low snap-acceleration opacities. This is confirmed by the data from the RTOS.

However, it is not clear that industry repair personnel can always properly diagnose the problems that cause these engines to have unexpectedly high smoke emissions. In the TRS, there were several instances of repairs of 1991 and newer engines which achieved only marginal reductions in smoke opacity. These results suggest that a 40 percent standard is a prudent choice to minimize the occurrence of false failures, even though it is plausible that 1991 and newer engines can be repaired to significantly lower opacity levels.

7. Exemptions with Substitute Standards.

There are a limited number of families of diesel engines that have snap-acceleration test opacities exceeding the relevant standard even when the engines, which satisfy U.S. EPA and California emission standards, are set to the manufacturers' specifications. These engines typically have sharply-peaked smoke profiles of short duration due to design of the engine and control systems. The current HDVIP regulations allow the manufacturers of these engine families to request that the ARB exempt the engine families from the relevant standard and substitute a technologically appropriate less stringent standard. For example, some models of engines in the Detroit Diesel Series 60, Caterpillar 3176, and Cummins L-10 engine families have been granted exemptions allowing snap-acceleration test opacities up to 75 percent.

Attenuating irrelevant sharp opacity peaks of short duration was a fundamental design goal of the SAE J1667 procedure. Use of the SAE J1667 procedure should, therefore, minimize the likelihood that properly maintained engines with sharp opacity peaks will fail to satisfy the relevant proposed standard. However, there is a possibility that properly maintained engines in some engine families may still have test opacities exceeding the standard.

The staff proposes that the current exemption process be retained to prevent false failures of this type. Exemptions for specific engine families that have been previously granted will be rolled over into the proposed HDVIP. For new exemption requests, manufacturers would have to provide the ARB with test data justifying the exemption, as at present. If the Executive Officer finds that the exemption request is technically sound and meets the requirements of the revised section 2182, an exemption will be granted. The staff will continue to work with engine manufacturers to assure that such exemption requests are processed smoothly and efficiently.

C. Issuance of Notices of Violation for Pre-1991 Model-Year Diesel Engines With Tested Opacities Between 55 Percent and 70 Percent

As noted above, staff has not supported the CTA's request that a 70 percent opacity standard be established for pre-1991 engines. Staff believes that a 55 percent standard is justified by the data and is consistent with AB 584.

An analysis of data from the suspended HDVIP and the RTOS suggests that a 70 percent standard is likely to reduce the number of citations issued by about 10 percent. During the suspended HDVIP, approximately 8.8 percent of the citations were issued to vehicles with opacities between 55 percent and 70 percent. About 13 percent of the complete RTOS sample (i.e., all model years) had opacities in the 55 to 70 percent range. In contrast, of the RTOS sample of pre-1991 vehicles with opacities exceeding 55 percent, 29 percent had opacities in the 55 to 70 percent range.

In order to maintain the emission reductions attributed to this program while making an accommodation for less culpable vehicle owners, the staff is proposing to maintain the 55 percent opacity standard with a NOV mechanism for pre-1991 engines with measured opacities exceeding 55 percent but not exceeding 69 percent. The proposal will result in a significantly greater number of trucks being repaired to opacities of 55 percent or less and thereby reducing emissions, compared to a 70 percent standard.

Under the proposed compromise, if vehicles with pre-1991 model year engines had snap-acceleration test opacities exceeding 55 percent the ARB would take the following actions:

- If the exceedance is above 69 percent, a citation imposing a financial penalty would be issued; second citations within a year would result in a penalty of $1800;
- If the opacity exceeds 55 percent but does not exceed 69 percent, an NOV (often referred to as a "fix-it ticket") would be issued;
- If a demonstration of correction is submitted within 45 days of receipt of the NOV, there will be no monetary penalty;
- If a demonstration of correction is not timely submitted, a citation would be issued and the normal penalties would apply.

The NOV mechanism would not apply where a previous NOV or citation has been issued f(le vehicle in the preceding 12 months. Where a pre-1991 engine inspected under the HDVIP has a measured opacity exceeding 55 percent but not exceeding 69 percent within 12 months of issuance of an NOV for which a timely demonstration of correction was issued, a citation will be issued with a penalty of $800. If the opacity is measured within that range and a citation had been issued for the vehicle within the preceding year, a citation will be issued and the penalty will be $1800 — the penalty applicable for second citations within a year. This higher penalty would apply for both prior citations issued in the first instance and prior citations issued after the owner failed to make timely repairs in response to an NOV.

The staff proposes that the above mechanism for pre-1991 model-year engines be reviewed after it has been in place for a year. The staff would report to the Board by December 31, 1999 on the results of enforcing this procedure and recommend whether the regulations should be amended to require that citations be issued to all vehicles with pre-1991 model year engines whose test opacity exceeds 55 percent. Any elimination of the NOV mechanism would need to be implemented in a subsequent rulemaking with the normal notice and comment period. (Because of projected fleet turn-over, the emissions impact of heavy-duty diesel vehicles with pre-1991 model year engines will be reduced over time.)

D. Interim Use of SAE J1243 Smokemeters

The present HDVIP and PSIP regulations specify the use of smokemeters complying with the specifications of SAE J1243. To facilitate a smooth transition from these smokemeters to the SAE J1667 type smokemeters specified in the proposed amendments, staff is proposing that facilities that are not equipped with a working SAE J1667 type smokemeter be permitted to conduct PSIP tests with SAE J1243 smokemeters until July 1, 1999. The measurements of opacities with SAE J1243 smokemeters would be subject to the testing procedures specified in the present HDVIP and PSIP regulations.

Vehicles brought into compliance using the older style SAE J1243 smokemeters will have greater assurance of compliance with the proposed standards because the older style smokemeters tend to read higher than newer SAE J1667 smokemeters.

E. Definition of "Excessive Smoke"

Assembly Bill 1460 (Stats. 1996, ch 292, Morrissey) amended Health and Safety Code section 44011.6(a) to prohibit the use of a heavy-duty vehicle that "emits excessive smoke." Accordingly, staff proposes a regulatory amendment providing that a heavy-duty vehicle has "excessive smoke" if it fails to comply with the applicable smoke opacity standard.

F. Administrative Hearing Process

As a further safeguard against possible false failures, owners of cited vehicles will continue to have administrative appeal rights. Under the existing HDVIP administrative hearing process, cited vehicle owners may contest a citation before a State-appointed Administrative Law Judge (ALJ). Under this process, a citee has 30 days from the day of service of the citation to request a hearing (this time period will be changed to 45 days). During the appeal, the citation is stayed, and the vehicle owner is not required to pay the civil penalties or take any other corrective actions until a decision is issued. At the hearing, the citee may present any information she/he believes is relevant to show that the citation was wrongfully issued. The administrative hearings will continue to be conducted by an impartial administrative law judge who has broad authority to take actions necessary for a full and fair adjudication of a contested citation. Under the administrative hearing procedures, citees may request that the ALJ's decision be reconsidered by the ARB's Executive Officer and may ultimately seek independent judicial review by filing a petition for a writ of administrative mandamus in Superior Court.

As noted above, the ARB is planning a separate rulemaking, with a hearing in the Spring of 1998, to update the administrative hearing regulations.

G. Issues of Controversy

In an August 1997 public mailout, draft proposed regulatory amendments, along with support documents including a draft Technical Support Document, were sent to interested parties. On September 11, 1997, the ARB staff conducted a public workshop to hear comments on the regulatory proposal. The current proposal reflects many of the comments received at the workshop, as well as those received prior and subsequent to it. Sections IV.B.5. and IV.C. address CTA's position that the opacity standard for pre-1991 model-year engines should be 70 percent. Staff is not aware of any other major issues of controversy.

V. ENVIRONMENTAL AND ECONOMIC IMPACTS

A. Identifying the Baseline for Evaluating the Impacts of the Proposed Amendments

Although the ARB has not yet resumed active enforcement of the HDVIP and the PSIP, the regulatory requirements have not been repealed and remain part of the California Code of Regulations. Accordingly, the analyses of the impacts of the proposed amendments set forth below are based on a comparison to the existing regulatory requirements, rather than a comparison to a situation where no heavy-duty inspection programs exist.

Following the evaluation of the environmental and economic impacts of the proposed amendments, this Section concludes with a discussion of the overall cost effectiveness of the HDVIP and PSIP. This cost effectiveness discussion is based on an analysis of the overall emissions benefits and costs of the roadside and fleet inspection programs.

B. Environmental Impacts of the Proposed Amendments

1. <u>Emissions Impacts</u>

As noted above, the staff's evaluation of the air quality impacts of the proposed amendments is based on a comparison of the HDVIP and PSIP with the proposed amendments, to the HDVIP and PSIP regulations as they now exist in the California Code of Regulations. In conducting an emissions impact analysis, it is also necessary to identify the "baseline" emissions starting point with which the original and amended programs will be compared. The staff has identified that baseline as the expected emissions from on-road heavy-duty diesel vehicles in 1998 prior to resumption of either the original or amended program. These estimated baseline emissions reflect the residual impact of the 1991-1993 HDVIP enforcement activities on the in-use emissions of heavy-duty trucks and buses in California.

In performing this analysis, staff modeled the years 1999 and 2010 using the MVEI7G emissions model as opposed to the Radian model used for the original program analyses. The MVEI7G is the current "state of the art" emissions model and reflects the most recent heavy-duty diesel vehicle inventory, activity and emission factors. As discussed in the Technical Staff Document, the staff updated the model in September 1997 to reflect the most recent repair data from the TRS and the resultant emission benefit factors. Based on the updated MVEI7G model, the environmental impacts presented in this section cover reactive organic gases (ROG), NOx, PM-10, and the percentage of smoking vehicles reduced (%). Except for the percentage of smoking vehicles reduced, all quantities are in the units of tons per day (tpd) statewide. The tables below summarize the combine incremental emissions reductions for the existing HDVIP and PSIP versus the programs as modified by the proposed amendments.

Table 4

Year 1999 - Incremental Emissions Reductions for Existing Programs vs. Proposed Amendments

	Existing Programs	Proposed Amendments	Difference
ROG (tpd)	7.71	6.37	-1.34
NOx (tpd)	14.70	12.24	-2.46
PM-10 (tpd)	6.30	5.24	-1.06
Smoking Vehicles Reduced (%)	35.4%	29.0%	-6.4%

The above table shows the incremental environmental impacts in 1999 for the existing program compared to the programs with the proposed amendments incorporated. As shown by the negative sign in the "difference" column, the benefits associated with the proposed amendments are slightly less than would be realized under the existing programs. The emissions reduced statewide are -1.34 tpd (ROG), -2.47 tpd(NOx), and -1.06 tpd (PM-10).

Table 5

Year 2010 - Incremental Emissions Reductions for Existing Programs vs. Proposed Amendments

	Existing Programs	Proposed Amendments	Difference
ROG (tpd)	7.22	5.30	-1.92
NOx (tpd)	19.13	14.03	-5.10
PM-10 (tpd)	4.37	3.19	-1.18
Smoking Vehicles Reduced (%)	48.9%	36.0%	-12.9%

Table 5, above, provides the same comparison as Table 4, but for the year 2010. Again the proposed amendments indicate that fewer benefits will be realized when compared incrementally to the existing program. For 2010, the differences are: -1.92 tpd, -5.10 tpd, and -1.18 tpd statewide for the emissions of ROG, NOx, PM-10, respectively.

With respect to smoking vehicles, the proposed amendments, when compared to the existing program, will be less effective because some heavy-duty vehicles that marginally exceed the opacity standards under the preexisting test procedures will not fail under the new text procedures. This lessens the overall reduction of "smoking" vehicles, but it is important to realize that the affected vehicles will be those that exceed the preexisting smoke requirements by the smallest amount. In 1999, the existing program would reduce the numbers of smoking vehicles by an estimated 35.4 percent while the proposed amendments will realize estimated reductions of 29.0 percent. In 2010, under the existing program smoking vehicles would be reduced by an estimated 48.9 percent, as compared to an estimated 35.7 percent if the proposed amendments are adopted.

As can be seen, the proposed amendments will result in fewer environmental benefits when compared on an incremental basis to the programs as they now exist in the California Code of Regulations. However, it bears emphasizing that resuming the amended program will result in significant emission reductions compared to the emissions experienced during the current hiatus. The causes for the reduced benefits are due primarily to the incorporation of the AB 584 requirements which direct the ARB to adopt the SAE J1667 testing protocol and smokemeters, and to ensure that there are no false failures or that any false failures will be remedied without penalty. The reduced benefits also reflect the proposed four-year rolling exemption under the PSIP. This exemption will allow newer fleet vehicles (less than 4 years old) to forego the annual smoke inspections. It is estimated that, while the exemption will affect approximately 26 percent of the fleet vehicles, these vehicles are expected to fail at a rate of less than 1 percent of the time. This exemption will allow limited inspection personnel to focus attention to vehicles of greater concern.

2. Effect on the State Implementation Plan

The 1994 State Implementation Plan (SIP) is California's strategy for attaining the federal ambient ozone standard. The 1994 SIP for ozone requires that current emissions of ozone precursors be reduced to meet the federal ozone ambient air quality standard. Although the HDVIP/PSIP were not included in the list of SIP control measures for ozone attainment, an estimate of the projected HDVIP/PSIP emissions benefits was included in the baseline emissions inventory for the SIP. Those projections were based an earlier emissions model (EMFAC7F) that reflected the impacts of heavy-duty vehicle repairs in a relatively rudimentary fashion. The projected year 2010 ROG + NOx emission benefits from the HDVIP/PSIP included in the baseline emissions inventory for the SIP was 5.9 tpd. Since the amended programs are now expected to result in year 2010 ROG+NOx emission benefits of 19.33 tpd, the amendments will not have an adverse impact on the ozone attainment demonstration in the SIP.

3. Other Environmental Impacts

The staff has not identified any significant non-emissions adverse environmental impacts that would result from the proposed amendments.

C. Economic Impacts Analysis of the Proposed Amendments

1. Legal Requirements

Section 11346.3 of the Government Code requires State agencies to assess the potential for adverse economic and cost impacts of proposed regulations on California business enterprises and individuals when proposing to adopt or amend any administrative requirements. The assessment shall include a consideration of the impact of the proposed regulation on California jobs; business expansion, elimination or creation; and the ability of California business to compete with businesses in other states.

Also, state agencies are required to estimate the cost or savings to any state or local agency and school district in accordance with instructions adopted by the Department of Finance. The estimate shall include nondiscretionary costs or savings to local agencies and the cost or savings in federal funding to the State.

2. Affected Businesses

Any business involved in the operation and service of heavy-duty diesel vehicles can potentially be affected by the proposed amendments. Also affected are businesses which manufacture the test equipment. All heavy-duty diesel trucks and buses operating on California roads,--whether they are operated by an intrastate, interstate or international owner--are subject to the HDVIP. According to the ARB's MVEI7G model, an estimated 570,561 and 777,214 heavy-duty diesel vehicles will be operating in California in 1999 and 2010 respectively. Approximately 81 percent of these vehicles or an estimated 462,164 in 1999 and 629,543 in 2010 will be registered in California. Of these California-registered vehicles, 63.1 percent will operate in fleets of two or more, and thus will also be subject to the requirements of the PSIP. These estimates compute to an estimated 291,625 vehicles in about 9,200 fleets subject to the PSIP in 1999, and an estimated 397,242 vehicles in about 12,600 fleets subject to the PSIP in 2010.

3. <u>Potential Impacts of the Amendments on Business</u>

Administrative costs to fleets. The PSIP results in various administrative costs for the operators of fleets containing two or more heavy-duty diesel powered vehicles that are registered in California. The PSIP administrative costs can be broken into three categories: labor costs, capital costs for acquisition of smokemeters, and the cost of contractual PSIP Inspections.

The proposed amendments do not change the basic PSIP requirement that fleet owners conduct annual smoke tests and inspections. The two significant changes made by the proposed amendments to the PSIP are (1) changing the smoke opacity test procedure from SAE J1243 to SAE J1667, and (2) exempting heavy-duty vehicles powered by 1994 and subsequent model year engines until those engines are more than four model years old. The TSD indicates that in-house inspections with company smokemeters will be more economical than contractual service testing when the fleet size exceeds 16 vehicles. The cost of SAE J1667 smokemeters are, on average, about the same as the cost of SAE J1243 smokemeters, according to a September 1997 survey conducted by staff and shown in Table 6 below. Further, the steps taken to conduct an SAE J1667 test are similar to those associated with an SAE J1243 test. Accordingly, the change in the test procedure is expected to have no significant impacts on the costs of labor or of contractual smoke tests, and, in most cases, the cost of smokemeters.

Table 6

Smokemeter Costs

	Meter A	Meter B	Meter C	Meter D
Cost of SAE J1243 Smokemeter	$3,000	$8,250	$4,995	$3,580
Cost of SAE J1667 Smokemeter	$4,500	$8,470	$4,995	$2,500
Cost to Upgrade from SAE J1243 to SAE J1667 Smokemeter	N/A	$200	$1,750	N/A

The one instance where the proposed change to the designated test procedure could have an adverse impact on fleet administrative costs involves firms that have already acquired an SAE J1243 type smokemeters and will need to replace it with an SAE J1667 type smokemeter. However, there are several factors that suggest that the overall costs associated with replacing SAE J1243 type smokemeters will be minimal. First, it appears that relatively few fleet operators acquired SAE J1243 type smokemeters in anticipation of complying with the PSIP. The ARB amended the regulations to delay implementation of the PSIP from January 1995 to January 1996 so that fleet operators would not have to buy SAE J1243 type smokemeters that would soon be outmoded. Second, as shown in Table 6 above, two manufacturers of more expensive smokemeters have substantially lower prices for replacing or updating SAE J1243 type instruments (in one case, the upgrade is only $200). Third, the proposed regulations include a grandfather clause that allows a facility that does not have an SAE J1667 type smokemeter to perform PSIP testing with an SAE J1243 type smokemeter until July 1, 1999. By that date, fleets that had purchased SAE J1243 type smokemeters several y s ago would be approaching the date the smokemeters would need to be replaced, since the estimated useful life of such smokemeters is 5-10 years.

With regard to the exemption for new engines during the first four model years, the staff estimates that 26 percent of the diesel engines in covered fleets will at any one time be no more than four model years old. Thus the exemption is expected to reduce fleet administrative costs by an average of 26 percent, although only those fleets with the newer engines will be affected. Overall, this reduction in cost would be expected to offset any additional costs resulting from a need to replace SAE J1243 smokemeters.

Other costs to heavy-duty vehicle owners. The remaining cost impacts for heavy-duty vehicle owners can be separated into four categories. These categories include the following:

- (a) repair costs for vehicles failing an HDVIP or PSIP test;
- (b) increased costs for improved maintenance conducted by owners in order to avoid HDVIP or PSIP failures;
- (c) the lost opportunity cost of time spent undergoing HDVIP inspections;
- (d) the savings from the reduced fuel costs that result from repairs and improved maintenance.

The staff estimates that, overall, the amendments will result in a very small cost savings for these categories, due to the slightly reduced failure rate under the new test procedure.

The minimal cost impacts of the proposed amendments on businesses are not expected to affect freight or passenger rates, or the costs of goods transported by heavy-duty diesel vehicles.

For the above reasons, the proposed amendments are not expected to have a significant adverse economic impact on large or small businesses, including the ability of California businesses to compete with businesses in other states, or on directly affected private persons. In addition, the proposed amendments should have no significant effect on the creation or elimination of jobs within the State of California, the creation of new businesses or elimination of existing businesses within California, or the expansion of businesses currently doing business within California.

4. Fiscal Impacts on State and Local Governmental Entities

A significant number of state and local agencies and school districts operate heavy-duty vehicles that are subject to the HDVIP and the PSIP. The cost analysis for businesses set forth above is equally applicable to these public entities. Accordingly, the amendments are not expected to result in an overall increase in costs for state and local entities.

D. Cost Effectiveness of the Overall Amended Programs

The preceding discussion analyzed the emission and economic impacts of the proposed amendments to the HDVIP and PSIP, comparing the programs as amended to the programs as they now exist in the California Code of Regulations. The discussion that follows analyzes the cost effectiveness of the *overall* programs with the proposed amendments. These cost effectiveness values are derived from the emission benefits and economic impacts of the amended programs, when compared with having no roadside or periodic inspection programs at all.

1. Emission Benefits of the Overall Programs

The implementation of the HDVIP and PSIP produces several overall benefits:

- A reduction in the number of heavy-duty diesel vehicles emitting excess smoke;
- A reduction in criteria and toxic air pollutant emissions from heavy-duty diesel vehicles;
- A reduction in heavy-duty diesel vehicle fuel consumption;
- A potential improvement in heavy-duty diesel vehicle reliability and performance.

As noted, the primary goal of the HDVIP and PSIP is to reduce the number of excessively-smoking heavy-duty diesel vehicles. Reductions in criteria and toxic air pollutants, reductions in fuel consumption, along with any improvements in vehicle reliability and performance are other benefits that will accrue as a result of repairing engines to manufacturer's specifications.

The reduction in the number of excessively-smoking heavy-duty diesel vehicles due to the implementation of the HDVIP and PSIP was estimated using data collected during the original HDVIP. During that program, the observed failure rate declined from 34 percent at the start of enforcement to 21 percent for the year 1993. This decline in failure rate can be directly converted to an estimate of the number of vehicles whose excess smoke emissions have been eliminated.

Based on the assumption that vehicle maintenance practices will equilibrate at the levels observed during the original HDVIP, the proposed amendments will reduce the number of excessively-smoking heavy-duty vehicles operating in California by approximately 29,000 in 1999, increasing to approximately 38,000 in 2010. This equates to reducing the number of excessively-smoking vehicles from California's roadways from 1999 through 2010 by approximately 625,000 due to the combined effects of the HDVIP and PSIP amendments.

The improved maintenance practices/repairs resulting from both the HDVIP and PSI program will also bring about a reduction in emissions of ROG, NOx and particulate. By using a "detailed engine malperformance model" along with the MVEI7G emissions inventory model, the statewide emission reduction impacts (in tons per day) are estimated as follows:

	ROG	NOx	PM-10
1999	6.37	12.24	5.24
2010	5.30	14.03[5]	3.19

This malperformance model was used to estimate changes in the volume of diesel fuel consumed by heavy-duty vehicles due to HDVIP and PSIP implementation. The estimated reduction in diesel fuel consumption of 0.69 percent in 1999 and 0.66 percent in 2010 translates to a savings of 16.7 million gallons of diesel fuel annually in 1999 and 19.2 million gallons of diesel fuel annually in 2010 or approximately 250 million gallons over the 12-year period, a savings of over $212 million based on current diesel fuel prices.

The renewed enforcement of the HDVIP and PSIP is also expected to cause reductions in the total toxic mass emissions from heavy-duty diesel vehicles and potentially improve heavy-duty diesel vehicle reliability and performance. However, due to the lack of definitive analytical tools for assessing the magnitude of these benefits, no quantitative estimate of program benefits in these areas has been developed

2. Costs of the Overall Programs

The Technical Support Document contains an extensive analysis of the estimated costs resulting from compliance with the HDVIP and the PSIP as amended by the staff's proposal. These costs are shown in Table 7.

When the overall costs of the HDVIP and PSIP are considered, it is likely that these costs will have no noticeable on the profitability of the California trucking industry, which earned about $1 billion in operating profit 1994 according to the U.S. Department of Commerce. In some instances, the programs can actually result in an increase in profitability for truck and bus operators because fuel cost savings that could result from timely repairs and improved maintenance would exceed the costs of inspections and repairs. The overall programs also benefit some businesses directly. Smokemeter manufacturers, testing stations, and repair and maintenance shops are likely to experience an increase in demand for their products and services.

3. Overall Cost Effectiveness

As discussed previously, the HDVIP and PSIP will reduce the emissions of criteria pollutants as a result the of repairs performed to reduce excessive smoke emissions. These reductions can be combined with program costs values to estimate the cost effectiveness of reducing criteria pollutants in terms of dollars per pound of emission reduction. Based on the estimated program costs and criteria pollutant emission reductions presented in the previous

[5] The TRS demonstrated that newer-technology diesel engines have greater NOx reductions per repair; increasing numbers of these newer-technology engines in the 2010 fleet will result in more NOx reductions realized than in 1999.

sections, the cost effectiveness of the benefits of the HDVIP and PSIP is estimated to be $1.12 per pound in 1999 and $1.05 per pound in 2010. These estimates compare favorably to alternative emission control programs which typically cost between $2.50 and $5.00 per pound of emissions reduced.

Table 7

Summary of HDVIP and PSIP Costs

	1999	2010
Administrative Cost to Fleets		
Annual Labor Cost (PSIP)	$1,255,761	$1,642,385
Annual Capital Cost for Smokemeters (PSIP)	$5,005,009	$6,817,787
Annual Cost of Contractual PSIP Inspections (PSIP)	$10,725,351	$14,027,474
Total Fleet Annual Administrative Cost	16,986,121	22,487,646
Costs to Vehicle Owners		
Annual Repair Cost (HDVIP + PSIP)	$21,162,379	$16,229,616
Annual Increased Maintenance Cost (HDVIP + PSIP)	$2,267,097	$2,947,141
Annual Lost Opportunity Cost of Time (HDVIP)	$771,936	$567,603
Annual Cost of Fuel (HDVIP + PSIP)	($21,764,145)	($24,983,116)
Total Cost to Vehicle Owners	$2,437,267	($5,238,756)
Total HDVIP and PSIP Cost		
Total Program Cost	$19,423,388	$17,248,890

Attachment A

Proposed Regulation Order

Proposed Regulation Order

Note: The preexisting regulation text is set forth below in normal type. The proposed amendments are shown in *italics* to indicate additions and ~~strikeout~~ to show deletions.

Amend Subchapter 3.5, Division 3, Title 13, California Code of Regulations (CCR) to read as follows:

~~Subchapter~~ *Chapter* 3.5. Heavy-Duty Diesel Smoke Emission Test*ing* ~~Procedure~~, and Heavy-Duty Vehicle Emission Control System Inspections

§ 2180. Applicability.

~~(a)~~ This ~~sub~~chapter applies to all diesel-powered and gasoline-powered heavy-duty vehicles, including pre-1974 model-year vehicles, operating in the State of California.

NOTE: Authority Cited: Sections 39600, 39601, 43013, and 44011.6, Health and Safety Code. Reference: Sections 39002, 39003, 39010, 39033, 43000, 43013, 43018, and 44011.6, Health and Safety Code.

§ 2180.1. Definitions.

(a) The definitions of this section supplement and are governed by the definitions set forth in Chapter 2 (commencing with ~~S~~*s*ection 39010), Part 1, Division 26 of the Health and Safety Code. The following definitions shall govern the provisions of this ~~sub~~chapter.

(1) "ARB post-repair inspection" means a repeat emission control system inspection, conducted by the Air Resources Board at an Air Resources Board-specified site, for the purpose of clearing a citation.

(2) "ARB post-repair test" means a repeat test, conducted by the Air Resources Board at an Air Resources Board-specified site, for the purpose of clearing a citation.

~~(1)~~*(3)* "Basic penalty" means the ~~reduced~~ civil penalty of ~~five hundred dollars~~ ($500) for a test procedure or emission control system inspection violation that is *to be* deposited in the Vehicle Inspection and Repair Fund.

~~(2) "Certification level" means the opacity for each 1974 and subsequent model-year heavy-duty diesel-powered engine when tested in accordance with Title 40, Code of Federal Regulations (CFR), Part 86.~~

~~(3)~~*(4)* "Citation" means a legal notice issued ~~to a heavy-duty vehicle's owner, or owner and operator,~~ by the Air Resources Board *to the owner of a heavy-duty vehicle* requiring the owner to repair the vehicle and to pay a civil penalty.

~~(4)~~*(5)* "Defective" means *a condition in which* an emission control system or an emission control system component ~~that~~ is malfunctioning due to age, wear, malmaintenance, or design defects.

~~(5)~~*(6)* "Demonstration of correction" means ~~a repair receipt from a repair facility, a completed work order from a fleet repair or fleet maintenance facility,~~ ~~*or a receipt for parts if the owner conducts his/her own repairs,*~~ *the documents identified in section 2186(a)* or successful completion of a*n ARB* post-repair test or inspection.

~~(6)~~*(7)* "Driver" has the same meaning as defined in California Vehicle Code section 305.

~~(7)~~*(8)* "Emission control label" means the label required by the "California Motor Vehicle Emission Control Label Specifications", incorporated by reference in 13 CCR, section 1965, or Title 40, Code of Federal Regulations (40 CFR), section 86.085-35 or 40 CFR Part 86, Subpart A.

~~(8)~~*(9)* "Emission control system" means the pollution control components on an engine at the time ~~of~~ its engine family ~~certification~~ *is certified*, including, but not limited to, the emission control label.

(~~9~~*10*) "Executive Officer" means the Executive Officer of the Air Resources Board or his or her designee.

(~~10~~*11*) "Fleet" means ~~three (3)~~ *two (2)* or more heavy-duty vehicles.

~~(11)~~ ~~"Full power position" means the throttle position at which the engine fuel delivery is at maximum flow.~~

(12) "Heavy-duty vehicle" means a *motor* vehicle having a manufacturer's maximum gross vehicle weight rating (GVWR) ~~of 6,001 or more~~ *greater than 6,000* pounds, *except passenger cars*.

(13) "Inspection procedure" means the test procedure specified in section 2182 and the emission control system inspection specified in section 2183.

(14) "Inspection site" means an area including a random roadside location, a weigh station, or a fleet facility used for ~~the purpose of~~ conducting the heavy-duty vehicle test procedure, emission control system inspection, or both.

(15) "Inspector" means an Air Resources Board employee ~~whose primary~~ *with the* duty *of* ~~is~~ enforcing Health and Safety Code section*s 43701(a) and* 44011.6, and Title 13, CCR section*s* 2180 *through 2194* ~~et seq~~.

(16) "Issuance" means the ~~date the~~ *act of mailing or personally delivering a* citation ~~is mailed to, or personally handed by an inspector~~ to~~,~~ the owner.

(17) "Minimum penalty" means the ~~three hundred dollar~~ ($300) penalty that is to be deposited in the Diesel Emission Reduction Fund ~~for State Energy Resources Conservation and Development Commission (CEC) programs~~ pursuant to Health and Safety Code section 44011.6~~(h)~~*(l)*.

(18) "Notice of Violation" means a legal notice issued to the owner of a heavy-duty vehicle powered by a pre-1991 model-year diesel engine with a measured smoke opacity exceeding 55 percent but not exceeding 69 percent, requiring the owner to repair the vehicle and submit a demonstration of correction.

(~~18~~*19*) "Officer" means a uniformed member of the Department of the California Highway Patrol.

(~~19~~*20*) "Opacity" means the percentage of light obstructed from passage through an exhaust smoke plume.

(~~20~~*21*) "Owner" means *either (A)* the person registered *as the owner of a vehicle* by the California Department of Motor Vehicles (DMV), or its equivalent in another state, ~~as the owner of the vehicle~~ *province, or country; or (B) a person shown by the registered owner to be legally responsible for the vehicle's maintenance. The person identified as the owner on the registration document carried on the vehicle at the time a citation is issued shall be deemed the owner unless that person demonstrates that another person is the owner of the vehicle.*

~~(21) "Post-repair inspection" means a repeat emission control system inspection for the purpose of determining compliance of a cited vehicle.~~

~~(22) "Post-repair test" means a repeat test for the purpose of determining compliance of a cited vehicle.~~

(~~23~~*22*) "Removal from service" means the towing and storage of a vehicle under the auspices of the Department of the California Highway Patrol.

(~~24~~*23*) "Repair facility" means any place where heavy-duty vehicles are repaired, rebuilt, reconditioned, or in any way maintained for the public at a charge, and fleet maintenance facilities.

(24) *"SAE J1667" means Society of Automotive Engineers (SAE) Recommended Practice SAE J1667 "Snap-Acceleration Smoke Test Procedure for Heavy-Duty Diesel Powered Vehicles," as issued February 1996 ("1996-02"), which is incorporated herein by reference.*

(25) "Schoolbus" means the same as defined in California Vehicle Code section 545.

(26) "Smokemeter" means a detection device used to measure the opacity for smoke in percent opacity *in accordance with SAE J1667.*

~~(27) "Snap-idle cycle" means rapidly depressing the accelerator pedal from normal idle to the full power position, holding the pedal in this position for no longer than ten seconds or until the engine reaches maximum speed, and fully releasing the pedal so that the engine decelerated to normal idle.~~

(~~28~~*27*) "Tampered" means missing, modified, or disconnected.

~~(29) "Test opacity" means the smokemeter measurement of opacity for the purpose of determining compliance with section 2182(a) through 2182(d).~~

~~(30) "Test procedure" means the preconditioning sequence and smoke opacity measurement processes for determining compliance with section 2182.~~

(~~31~~*28*) "Uncleared citation" means a citation for which demonstration of correction and, if required, payment of any civil penalty, has not been made.

NOTE: Authority Cited: Sections 39600, 39601, 43013, and 44011.6, Health and Safety Code. Reference: Sections 39002, 39003, 39010, 39033, 43000, 43013, 43018, and 44011.6, Health and Safety Code. Section 505, Vehicle Code.

§ 2181. Responsibilities *of the Driver and Inspector* During the Inspection Procedure.

(a) ***Driver of heavy-duty diesel-powered vehicle.*** The driver of a heavy-duty diesel-*powered* vehicle selected to undergo the inspection procedure shall do all of the following:

(1) Drive the vehicle to the inspection site upon direction of an officer.

(2) Perform the test procedure upon request by an inspector.

(3) Open the vehicle door so that the inspector can observe the driver depress the accelerator pedal.

(4) Permit an emission control system inspection upon the request of the inspector.

(5) Sign the citation *or notice of violation* to acknowledge its receipt and the smoke test ~~strip chart~~ *report* to acknowledge performance of the test procedure.

(b) ***Driver of heavy-duty gasoline-powered vehicle.*** The driver of a heavy-duty gasoline-*powered* vehicle selected to undergo the inspection shall:

(1) Drive the vehicle to the inspection site upon direction of an officer.

(2) Permit an emission control system inspection upon request of the inspector.

(3) Sign the citation to acknowledge its receipt.

(c) ***Inspector.*** The inspector in performing the inspection procedure shall do all of the following:

(1) Advise the driver that refusal to submit to the inspection procedure is a violation of these regulations.

(2) Obtain engine identification information from ~~a~~ *the* vehicle when tested pursuant to section 2182~~(h)~~ to determine which opacity standard specified in section 2182~~(a) through 2182(b) would apply~~ *applies*.

(3) *Except as otherwise provided in section 2181(c)(4),* ~~I~~issue a copy of the citation to the driver of a vehicle that fails the test procedure or the emission control system inspection.

(4) Issue a copy of the notice of violation to the driver of a vehicle powered by a pre-1991 model-year diesel engine with a measured smoke opacity exceeding 55 percent but not exceeding 69 percent, except where a notice of violation or citation has been issued for the vehicle in the preceding 12 months.

~~(4)~~*(5)* Issue a warning to the owner of a heavy-duty diesel-powered vehicle missing its emission control label that ~~the engine serial or identification number~~ *the label* must be ~~provided to the ARB within thirty (30) calendar days or it will be conclusively presumed that the vehicle has a certification level equal to or less than thirty-five (35) percent peak smoke opacity.~~ *replaced and the engine number identification must be provided to the ARB within 30 days of written notification by the ARB, or it will be conclusively presumed in any subsequent smoke opacity test where the emission control label remains missing that the vehicle is subject to the 40 percent smoke opacity standard in section 2182(a)(1), unless at the time of the subsequent test it is plainly evident from a visual inspection that the vehicle is powered by a pre-1991 model-year engine.*

NOTE: Authority Cited: Sections 39600, 39601, 43013, and 44011.6, Health and Safety Code. Reference: Sections 39002, 39003, 39010, 39033, 43000, 43013, 43018, and 44011.6, Health and Safety Code. Section 305, Vehicle Code.

§ 2182. Heavy-Duty Diesel Vehicle Smoke Opacity *Standards and* Test Procedures*; Excessive Smoke*

(a) ***Standards***

(1) No ~~1974 or subsequent model-year~~ heavy-duty ~~diesel-powered~~ vehicle *powered by a 1991 or subsequent model-year diesel engine* ~~with a Federal peak smoke engine certification level of thirty-five (35) percent peak opacity or less~~ operating on the highways within the ~~s~~*S*tate of California shall exceed ~~forty (~~40~~)~~ percent ~~peak~~ smoke opacity when tested in accordance with this section unless its engine is exempted under subsection (c) or (d) below.

~~(b)~~ *(2)* No ~~other~~ heavy-duty ~~diesel-powered~~ vehicle *powered by a pre-1991 model-year diesel engine,* operating on the highways within the ~~s~~*S*tate of California, ~~including pre-1974 model-year vehicles~~ shall exceed ~~fifty-five (~~55~~)~~ percent ~~peak~~ smoke opacity when tested in accordance with this section unless its engine is exempted under subsection (c) or (d) below.

~~(c)~~*(b)* ***Exemptions***

(1) The Executive Officer shall exempt from ~~the operation of~~ subsections (a)*(1) and (2)* ~~and (b) above~~ any engine family ~~that he/she determines~~ *that is shown by the engine manufacturer to the satisfaction of the Executive Officer to* exhibit ~~snap-idle test results~~ *smoke opacity* greater than ~~forty (~~40~~)~~ percent ~~under (a)~~ or ~~fifty-five (~~55~~)~~ percent ~~under (b)~~ *respectively* when in good operating condition and adjusted to the manufacturer's specifications. Such engine family(s) must comply with ~~the~~ *any* technologically appropriate ~~higher~~ *less stringent* opacity standard ~~determined~~ *identified* by the Executive Officer ~~from~~ *based on* a review of the data obtained from engines in good operating condition and adjusted to manufacturer's specifications.

~~(d)~~*(2)* The Executive Officer shall exempt from ~~the operation of~~ subsections (a)*(1) and (2)* ~~and (b) above~~ any 1991 and earlier model-year heavy-duty diesel ~~vehicles~~ *engines that are* equipped with carryover add-on aftermarket turbocharger kits approved by the ARB, ~~that he/she determines~~ *and are shown by the kit or engine manufacturer to the satisfaction of the Executive Officer to* exhibit ~~snap-idle test results~~ *smoke opacity* greater than ~~forty (~~40~~)~~ percent ~~under (a)~~ or ~~fifty-five (~~55~~)~~ percent ~~under (b)~~ *respectively* when in good operating condition and adjusted to the manufacturer's specifications. Such engine*s* ~~family(s)~~ must comply with ~~the~~ *any* technologically appropriate ~~higher~~ *less stringent* opacity standard ~~determined~~

identified by the Executive Officer ~~from~~ *based on* a review of the data obtained from engines in good operating condition and adjusted to manufacturer's specifications.

(3) *Exemptions previously issued and in effect on January 1, 1996 shall remain in effect under the amendments to this section adopted on [insert date] and effective on [insert date].*

~~(e)~~ ~~In the event that a 1974 or later model-year heavy-duty diesel-powered vehicle's engine identification cannot be obtained by the inspector in order to determine the Federal smoke certification level, the owner, within thirty (30) calendar days of the inspection, shall provide the ARB with the engine identification information. If the owner fails to comply with this requirement, it is conclusively presumed for the purpose of subsequently performing the test procedure that the vehicle has a Federal peak smoke certification level equal to or less than thirty-five (35) percent peak smoke opacity and that the peak smoke opacity standard is forty (40) percent.~~

~~(f)~~ *(4)* ~~Manufacturers of heavy-duty diesel-powered engines shall provide to the ARB the certification levels by model-year for each engine family that it has certified to levels above thirty-five (35) percent peak opacity within sixty (60) calendar days after receiving Federal or California engine certification approval.~~ *A* ~~M~~*m*anufacturer~~s~~ *seeking an exemption under subsection (b)* shall ~~further~~ provide ~~to~~ the ARB *with the* engine emissions data ~~as necessary for the Executive Officer to make exemption determinations and determinations of~~ *needed to exempt the engine family and determine* technologically appropriate ~~higher~~ *less stringent* opacity standards ~~under subsections (c) or (d) above within sixty (60) calendar days after receiving Federal or California engine certification approval. The Executive Officer may extend this sixty (60) calendar day period upon the request of an engine manufacturer if the engine manufacturer can demonstrate that he/she cannot collect the engine emissions data within 60 days. The engine manufacturers shall further provide to the ARB a complete list of engine identification numbers for these engines when this information becomes available~~.

(c) ***Effect of missing emission control label on applicable standard.*** *When the owner of a heavy-duty diesel-powered vehicle receives written notification from the ARB that the emission control label was missing during an inspection, the owner must replace the emission control label and provide the engine number identification to the ARB within 30 days of receipt of the notification. If the owner fails to comply with this requirement, it will be conclusively presumed in any subsequent smoke opacity test where the emission control label remains missing that the vehicle is subject to the 40 percent smoke opacity standard in section 2182(a)(1), unless at the time of the subsequent test it is plainly evident from a visual inspection that the vehicle is powered by a pre-1991 model-year engine.*

(d) ***Excessive smoke.*** *A heavy-duty vehicle has excessive smoke if it fails to comply with the smoke opacity standard applicable under this section 2182.*

~~(g)~~*(e)* ***Test Procedures.*** *For purposes of this chapter 3.5, smoke opacity shall be determined in accordance with SAE J1667.* ~~The smoke opacity measurement equipment shall consist of a light extinction type smokemeter which includes an optical detection unit, a control/indicator unit, and a strip chart recorder.~~

~~(1)~~ ~~The smokemeter shall comply with the specifications provided in the Society of Automotive Engineers (SAE) procedure J1243, "Diesel Emission Production Audit Test Procedure," May 1988, which is incorporated herein by reference, section 7.4 and shall be calibrated according to specifications in SAE procedure J1243, section 8.2.~~

~~(2)~~ ~~The strip chart recorder shall comply with specifications in SAE procedure J1243, section 7.5, subsections 1-4 (May 1988).~~

~~(h)~~ ~~The test procedure shall consist of preparation, preconditioning, and test phases:~~

~~(1)~~ ~~In the preparation phase, the vehicle shall be placed at rest, the transmission shall be placed in neutral, and the vehicle wheels shall be properly restrained to prevent any rolling motion.~~

~~(2)~~ ~~In the preconditioning phase, the vehicle shall be put through a snap-idle cycle two or more times until two successive measured smoke levels are within ten (10) opacity percent of each other. The smoke meter shall be rechecked prior to the preconditioning sequence to determine that its zero and span setting are adjusted according to specifications in SAE procedure J1243, section 8.1 (May 1988).~~

~~(3)~~ ~~In the test procedure phase, the vehicle shall be put through the snap-idle cycle three times.~~

~~(4)~~ ~~The opacity shall be measured during the preconditioning and test phases with a smokemeter and shall be recorded continuously on the chart recorder during each snap-idle cycle. The maximum instantaneous value recorded by the chart recorder shall be the opacity reading.~~

~~(5)~~ ~~The test opacity to determine the compliance with (a) through (b) above shall be the average of the two meter readings with the least difference in opacity values. If all three readings have successive equivalent differences between them, the test opacity shall be the average of the three readings.~~

NOTE: Authority Cited: Sections 39600, 39601, 43013, and 44011.6, Health and Safety Code. Reference: Sections 39002, 39003, 39010, 39033, 43000, 43013, 43018, and 44011.6, Health and Safety Code.

§ 2183. ~~Heavy-Duty Vehicle~~ *Inspection of the* Emission Control System ~~Inspection~~ *on a Heavy-Duty Vehicle*

(a) ***Heavy-duty diesel-powered vehicles.*** The heavy-duty diesel-powered vehicle emission control components subject to inspection for tampered or defective conditions include, but are not limited to, the following:

(1) The engine governor.

(2) Any seals and/or covers protecting the air-fuel ratio adjustments.

(3) Any fuel injection pump seal and covers.

(4) The air cleaner and flow restriction indicator.

(5) The exhaust gas recirculation valve.

(6) The particulate matter trap system or catalytic converter system, including pipes and valves.

(7) Related hoses, connectors, brackets, and hardware for these components.

(8) Engine computer controls, related sensors, and actuators.

(9) Emission control label.

(10) Any other emissions-related components for a particular vehicle/engine as determined from the manufacturer's specifications, emission control label, certification data, or published vehicle parts manuals.

(b) ***Heavy-duty gasoline-powered vehicles.*** The heavy-duty gasoline-powered vehicle emission control components subject to inspection for tampered or defective conditions, include, but are not limited to, the following:

(1) The air injection system.

(2) The positive crankcase ventilation system.

(3) The exhaust gas recirculation system.

(4) The catalytic converter, including pipes and valves.

(5) The evaporative emission control system.

(6) Related hoses, connectors, brackets, and hardware for these components.

(7) Engine computer controls, related sensors, and actuators.

(8) On-Board Diagnostic (OBD) systems for 1994 and subsequent model year vehicles, if so equipped.

(9) Emission control label.

(10) Any other emissions-related component for a particular vehicle/engine as determined from the manufacturer's specifications, emission control label, certification data, or published vehicle parts manuals.

NOTE: Authority Cited: Sections 39600, 39601, 43013, and 44011.6, Health and Safety Code. Reference: Sections 39002, 39003, 39010, 39033, 43000, 43013, 43018, and 44011.6, Health and Safety Code.

§ 2184. Refusal to Submit to Inspection Procedure.

~~(a)~~ The refusal by an owner or driver of a vehicle to submit to the test procedure in section 2182 or to the emission control system inspection in section 2183 constitutes a failure of the test procedure or inspection, unless the driver is cited by the California Highway Patrol for a violation of California Vehicle Code section 2813.

NOTE: Authority Cited: Sections 39600, 39601, 43013, and 44011.6, Health and Safety Code. Reference: Sections 39002, 39003, 39010, 39033, 43000, 43013, 43018, and 44011.6, Health and Safety Code. Sections 305, 505, and 2813, Vehicle Code.

§ 2185. Civil Penalty Schedule.

(a) The owner of a heavy-duty vehicle that fails the test procedure or the emission controls system inspection, including by refusal to submit, is subject to the following penalty schedule:

(1) The owner of a vehicle, other than a schoolbus, that is cited for the first time *pursuant to section 2182 or 2183* and for which demonstration of correction is provided and payment is made within ~~forty-five (~~45~~) calendar~~ days from personal or certified mail receipt of the citation, shall pay the minimum penalty of ~~three hundred dollars (~~$300~~)~~.

(2) The owner of a vehicle that is cited for the first time *pursuant to section 2184, or that is cited for the first time pursuant to sections 2182 or 2183* and for which demonstration of correction is not provided within ~~forty-five (~~45~~) calendar~~ days from personal mail or certified mail receipt of the citation, shall provide

demonstration of correction and pay the minimum penalty of ~~three hundred dollars (~~$300~~)~~ and the basic penalty of ~~five hundred dollars (~~$500~~)~~ for a total of ~~eight hundred dollars (~~$800~~)~~. Schoolbuses are exempt from the ~~three hundred dollar (~~$300~~)~~ minimum penalty for the first violation only.

(3) The owner of a vehicle that is cited within ~~one year~~ *12 months* from the issuance of ~~a previous~~ *the most recent* citation for that vehicle shall within ~~forty-five (45) calendar~~ days from personal or certified mail receipt of the current citation provide demonstration of correction and pay the penalty of ~~one thousand five hundred dollars (~~$1,500~~)~~ and the minimum penalty of ~~three hundred dollars (~~$300~~)~~ for a total of ~~one thousand eight hundred dollars (~~$1,800~~)~~.

~~(b) The owner of a pre-1991 vehicle that within one year after the effective date of these regulations exceeds the standard in section 2182(a), but has a smoke level less than or equal to fifty-five (55) percent peak opacity, shall be advised of that failure, but shall not be required to pay any penalty~~.

~~(1) The Executive Officer shall monitor this phase-in period and may extend the one-year period in one-year increments provided that the Air Resources Board post repair tests show that the level of repair effectiveness in reducing excessive smoke emissions does not justify implementing the 2182(a) standard. The Executive Officer shall hold a workshop(s) to assist in making this determination.~~

(b) (1) No citation shall be issued to the owner of a heavy-duty vehicle powered by a pre-1991 model-year diesel engine on the basis of a measured smoke opacity exceeding 55 percent but not exceeding 69 percent, unless:

(A) the owner fails to provide a demonstration of correction within 45 days from personal or certified mail receipt of the notice of violation, or

(B) a notice of violation or citation has been issued for the vehicle in the preceding 12 months.

(2) The owner of a vehicle that is the subject of a notice of violation and for which demonstration of correction is provided within 45 days from personal or certified mail receipt of the notice of violation shall not be subject to a penalty for the violation.

(3) The owner of a vehicle that is initially subject to a notice of violation, but is cited after a demonstration of correction is not provided within 45 days from personal or certified mail receipt of a notice of violation, shall be subject to the penalty in section 2185(a)(2).

(4) (A) Where a heavy-duty vehicle with a pre-1991 engine inspected in accordance with section 2181 has a measured opacity exceeding

55 percent but not exceeding 69 percent within 12 months of issuance of a notice of violation for which a demonstration of correction was timely provided within the applicable 45-day period, a citation shall be issued and the owner shall be subject to the penalty in section 2185(a)(2).

(B) *Where a heavy-duty vehicle with a pre-1991 engine inspected in accordance with section 2181 has a measured opacity exceeding 55 percent but not exceeding 69 percent within 12 months of issuance of a notice of violation for which a demonstration of correction was not timely provided within the applicable 45-day period, a citation shall be issued and the owner shall be subject to the penalty in section 2185(a)(3).*

(c) If a vehicle fails the test procedure or an emission control system inspection one year or more after the date of its ~~previous~~ *most recent* failure, the owner of that vehicle shall be subject to the penalty schedule in *section 2185*(a)(1) and (2) ~~above~~.

(d) *When a vehicle is cited after* ~~If~~ a bona fide change of ~~vehicle~~ ownership ~~occurs~~ between non-related persons or entities, ~~and the vehicle is subsequently cited within one year of the previous citation, the new owner shall be subject to the penalty schedule in (a) (1) and (2) above.~~ *the new owner shall be subject to the penalty schedule in section 2185(a)(1) and (2) if the only citations issued for the vehicle within the previous 12 months were issued prior to the change of ownership to the new owner.*

(e) An owner who has been cited twice or more for tampered emission controls on the same vehicle shall be subject to the penalty in *section 2185*(a)(3) ~~above~~, *notwithstanding section 2185(c).*

NOTE: Authority Cited: Sections 39600, 39601, 43013, and 44011.6, Health and Safety Code. Reference: Sections 39002, 39003, 39010, 39033, 43000, 43013, 43018, and 44011.6, Health and Safety Code. Sections 305, 505, and 545, Vehicle Code.

§ 2186. Demonstration of Correction and Post-Repair Test or Inspection.

(a) The owner may demonstrate correction of the vehicle by submitting to the Air Resources Board *the following documents:*

(1) *Where repairs are made at a repair facility,* a repair receipt ~~from a repair facility~~ or a completed work order ~~from a fleet repair or maintenance facility~~ which contains the following information:

~~(1)~~ *(A)* Name, address, and phone number of the facility~~.~~;

~~(2)~~ *(B)* Name of mechanic~~.~~;

~~(3)~~ *(C)* Date of the repair~~.~~*;*

~~(4)~~ *(D)* Description of component replacement(s), repair(s), and/or adjustment(s)~~.~~*; and*

~~(5)~~ *(E)* Itemized list of replaced component(s), including description of part, part number, and cost.

(2) Where the owner makes his or her own repairs outside of a repair facility,

(A) An itemized receipt for the parts used in the repair, and

(B) A statement identifying the date and nature of the repairs made.

(3) Where the citation or notice of violation was based on a failure to meet the opacity standard applicable under section 2182, a smoke test report from a subsequent test showing that the repaired vehicle passed the applicable section 2182 standard along with a statement to that effect made under penalty of perjury by the person who conducted the subsequent test.

(4) Where the citation was based on a failure to pass an emission control system inspection as specified in section 2183, a statement by a person, under penalty of perjury, that the person has reinspected any components identified in the citation as defective or tampered and has determined that these components are in good working order.

(b) In lieu of submitting ~~a repair receipt or a completed work order~~ *the documents identified under section 2186(a)*, the owner may demonstrate correction of the vehicle by submitting it to a*n ARB* post-repair test or a*n ARB* post-repair inspection.

(c) The Air Resources Board shall require a*n ARB* post-repair test *or an ARB post-repair* inspection whenever:

(1) a submitted repair receipt or work order does not comply with (a) above;

(2) a repair receipt or work order appears to be falsified; or

(3) a second and subsequent failures of the test procedure or an emission control system inspection on the vehicle occur within a one-year period.

NOTE: Authority Cited: Sections 39600, 39601, 43013, 44011.6, Health and Safety Code. Reference: Sections 39002, 39003, 39010, 39033, 43000, 43013, 43018, and 44011.6, Health and Safety Code. Section 505, Vehicle Code.

§ 2187. Vehicles Removed from Service.

(a) Vehicles are subject to removal from service by the Department of the California Highway Patrol if requested by the Air Resources Board inspector, and if one or more uncleared citations exist at the time of inspection.

(b) Upon payment by cashier's check or money order of all unpaid penalties for a vehicle that has been removed from service, the Air Resources Board shall provide the owner, or designee, a release form for presentation to the Department of the California Highway Patrol.

(c) The release of the vehicle shall be subject to the condition that it be repaired and post-repair tested or inspected within ~~fifteen (15) calendar~~ days.

NOTE: Authority Cited: Sections 39600, 39601, 43013, 44011.6, Health and Safety Code. Reference: Sections 39002, 39003, 39010, 39033, 43000, 43013, 43018, and 44011.6, Health and Safety Code.

§ 2188. Contesting a Citation.

The owner of a vehicle cited under these regulations may request a hearing pursuant to sections 60075.1 et seq., Title 17, California Code of Regulations.

NOTE: Authority Cited: Sections 39600, 39601, 43013, 44011.6, Health and Safety Code. Reference: Sections 39002, 39003, 39010, 39033, 43000, 43013, 43018, and 44011.6, Health and Safety Code.

Amend Subchapter 3.6, Sections 2190-2194, Title 13, California Code of Regulations, to read as follows:

~~Subchapter~~ *Chapter* 3.6. *Periodic Smoke Inspections of* Heavy-Duty Diesel-Powered Vehicle*s* ~~Periodic Smoke Inspections~~

§ 2190. *Vehicles Subject to the Periodic Smoke Inspection Requirements*

These regulations shall be applicable, effective ~~January 1, 1996~~ *July 1, 1998,* as follows:

(a) Except as provided in subsections (b), (c), (d), (e) and (f), the requirements of this ~~subchapter~~ *chapter* apply to all heavy-duty diesel-powered vehicles with gross vehicle weight ratings of 6,001 pounds or more which operate on the streets or highways within the State of California.

(b) Heavy-duty diesel-powered vehicles which are not part of a fleet ~~(as defined in section 2191(a))~~ are excluded from the requirements of this ~~subchapter~~ *chapter*.

(c) Heavy-duty diesel-powered vehicles which are registered under the International Registration Plan as authorized by Article 4 (commencing with section 8050), Chapter 4, Division 3 of the Vehicle Code and which have established a base state other than California (non-California based vehicles) are excluded from the requirements of this ~~subchapter~~ *chapter*.

(d) Heavy-duty diesel-powered vehicles which operate in California under the terms of Interstate Reciprocity Agreements as authorized by Article 3 (commencing with section 8000), Chapter 4, Division 3 of the Vehicle Code and which belong to fleets that are not based in California are excluded from the requirements of this ~~subchapter~~ *chapter*.

(e) Heavy-duty diesel-powered vehicles operating in California under the terms of any other apportioned registration, reciprocity, or bilateral prorate registration agreement between California and other jurisdictions and which belong to fleets that are not based in California are excluded from the requirements of this ~~subchapter~~ *chapter*.

(f) Heavy-duty diesel-powered vehicles operating in California under short-term vehicle registrations or permits of 90 days or less (including but not limited to 90-day temporary registrations and 4-day permits under Vehicle Code section 4004) are excluded from the requirements of this ~~subchapter~~ *chapter*.

NOTE: Authority Cited: Sections 39600, 39601, and 43701(a), Health and Safety Code. Reference: Sections 39002, 39003, 39010, 39033, 43000, 43018, 43701(a), and 44011.6, Health and Safety Code.

§ 2191. Definitions.

(a) The definitions of this section supplement and are governed by the definitions set forth in Chapter 2 (commencing with Section 39010), Part 1, Division 26 of the Health and Safety Code. The provisions of this ~~subchapter~~ *chapter* shall also be governed by the definitions set forth in section 2180.1, Title 13, California Code Regulations including the following modifications:

(1) "Fleet" means any group of 2 or more heavy-duty diesel-powered vehicles which are owned or operated by the same agency or entity.

~~(2)~~ ~~"Inspector" means an Air Resources Board employee with the duty of enforcing Health and Safety Code sections 43701(a) and Title 13, California Code of Regulations, sections 2190 through 2194~~.

(~~3~~ *2*) "Test opacity" means the ~~measurement of smoke~~ opacity *of smoke* from a vehicle ~~for the purpose of determining compliance with the standards referenced in~~ *when measured in accordance* section 2193~~(c)~~*(e)*.

~~(4)~~ ~~"Test procedure" means the smoke meter test procedure as specified in section 2193(c).~~

NOTE: Authority Cited: Sections 39600, 3960[illegible] and 43701(a), Health and Safety Code. Reference: Sections 39002, 39003, 39010, 39033, 43000, 43018, 43701(a), and 44011.6, Health and Safety Code.

§ 2192. Vehicle Inspection Responsibilities.

(a) The owner of a heavy-duty diesel-powered vehicle subject to the requirements of this ~~subchapter~~ *chapter* shall do all of the following:

(1) Test the vehicle for excessive smoke emissions periodically according to the inspection intervals specified in section 2193(a), ~~and~~ (b), *and (c)*.

(2) Measure the smoke emissions for each test using the test procedure specified in section 2193~~(c)~~*(e)*.

(3) Record the smoke test opacity levels and other required test information as specified in section 2194.

(4) Have the vehicle repaired if it exceeds the applicable smoke opacity standard specified in section 2193~~(c)~~*(e)*.

(5) Record the vehicle repair information as specified in section 2194.

(6) Conduct a post-repair smoke test to determine if the vehicle complies with the applicable smoke opacity standard.

(7) Record the post-repair smoke test results as specified in section 2194.

(8) If the vehicle does not comply with the applicable smoke opacity standard *after the test required by section 2192(a)(7)*, make additional repairs to achieve compliance, and record the smoke test results as specified in section 2194.

(9) Keep the records specified in section 2194 for two years after the date of inspection.

(10) Permit an Air Resources Board inspector to review the inspection records specified in section 2194 at owner/operator designated fleet locations by appointment.

NOTE: Authority Cited. Sections 39600, 39601, and 43701(a), Health and Safety Code. Reference: Sections 39002, 39003, 39033, 43000, *43016*, 43018, 43701(a), and 44011.6, Health and Safety Code.

§ 2193. Smoke Opacity Inspection Intervals, *Standards, and* Test Procedures~~, and Standards~~.

(a) ***Initial phase-in.*** Vehicles which are subject to the requirements of this ~~subchapter~~ *chapter* on the effective date of these regulations shall be tested for smoke opacity (and repaired if the applicable smoke opacity standard is exceeded) in accordance with the requirements of section 2192 pursuant to the *applicable* following schedule:

(1) *Fleets of five or more vehicles subject to this chapter:*

(A) ~~at~~ *At* least 25 percent of the fleet's vehicles within 180 calendar days of the effective date of these regulations;

(B) ~~at~~ *At* least 50 percent of the fleet's vehicles within 270 calendar days of the effective date of these regulations;

(C) ~~at~~ *At* least 75 percent of the fleet's vehicles within 365 calendar days of the effective date of these regulations; and~~;~~

(D) ~~the~~ *The* ~~remaining~~ fleet's *remaining* vehicles no later than 455 calendar days after the effective date of these regulations.

(2) For fleets of 2 to 4 vehicles, at least one vehicle must be tested in *the initial 180 day period, and in* each *subsequent* 90 calendar day period, ~~beginning with the initial 180 calendar day period,~~ until all vehicles in the fleet have been tested.

(b) *New fleets.* Fleets which *first* become subject to the requirements of ~~the subchapter~~ *this chapter* subsequent to the effective date of these regulations ~~should~~ *must* be tested in accordance with *section 2192 within* the *applicable time intervals reflected in subsection (a)* above, ~~schedule~~ beginning on the date ~~they~~ *the fleet* becomes subject to these regulations.

~~(b)~~*(c)* ***Annual testing.*** ~~After the initial smoke opacity testing under subsection (a),~~ *Once a* vehicle~~s which are~~ subject to the requirements of this ~~subchapter~~ *chapter has been tested in accordance with subsection (a) or (b), or has been acquired by a fleet owner after the effective date of these regulations, the vehicle must periodically* ~~shall~~ be tested for smoke opacity (and repaired if the applicable smoke opacity standard is exceeded) in accordance with the requirements of section 2192 ~~at least once every 365 days~~ *within 12 months of the previous test conducted under this section 2193.*

(d) ***Exemption for vehicles powered by 1994 or subsequent model-year engines.*** *Any heavy-duty vehicle powered by a 1994 or subsequent model-year engine is exempt from the testing requirements of this section until January 1 of the calendar year that is four years after the model year of the engine, and is to be treated as having been acquired by the owner on that January 1. For example, a 1995 model-year engine will be exempt until January 1, 1999.*

~~(c)~~*(e)* ***Smoke opacity standards and test procedures.***

(1) *Except as otherwise provided in subsection (e)(2) below, t*~~T~~he smoke opacity *standards and* test procedures ~~and applicable opacity standards shall be as~~ *are those* specified in section 2182~~(a) to (e), (g), and (h)~~, Title 13, California Code of Regulations.

(2) Prior to July 1, 1999, if a repair facility is not equipped with an operable SAE J1667 smokemeter, vehicles may be tested at the repair facility in accordance with the smoke opacity test procedures and opacity standards set forth in section (e)(3). These are the test procedures and opacity standards originally established for the heavy-duty diesel vehicle roadside inspection program in 1991.

(3) ***Optional smoke opacity test procedures and standards prior to July 1, 1999.***

(A) ***Standards.***

1. The maximum smoke opacity standard for a 1991 or subsequent model-year heavy-duty diesel-powered vehicle with a Federal peak smoke engine certification level of 35 percent peak opacity or less is 40 percent when tested in accordance with section 2193(e)(3)(B) and (C).

2. *The maximum smoke opacity standard for any other heavy-duty diesel-powered vehicle is 55 percent when tested in accordance with section 2193(e)(3)(B) and (C).*

3. *The above standards do not apply to an engine exempted under section 2182(b).*

(B) ***Equipment.*** *The smoke opacity measurement equipment shall consist of a light extinction type smokemeter which includes an optical detection unit, a control/indicator unit, and a strip chart recorder.*

1. *The smokemeter shall comply with the specifications provided in the Society of Automotive Engineers (SAE) procedure J1243, "Diesel Emission Production Audit Test Procedure," May 1988, which is incorporated herein by reference, section 7.4 and shall be calibrated according to specifications in SAE procedure J1243, section 8.2.*

2. *The strip chart recorder shall comply with specifications in SAE procedure J1243, section 7.5, subsections 1-4 (May 1988).*

(C) ***Procedure.*** *The test procedure shall consist of preparation, preconditioning, and test phases:*

1. *In the preparation phase, the vehicle shall be placed at rest, the transmission shall be placed in neutral, and the vehicle wheels shall be properly restrained to prevent any rolling motion.*

2. *In the preconditioning phase, the vehicle shall be put through a snap-idle cycle two or more times until two successive measured smoke levels are within ten (10) opacity percent of each other. The smoke meter shall be rechecked prior to the preconditioning sequence to determine that its zero and span setting are adjusted according to specifications in SAE procedure J1243, section 8.1 (May 1988).*

3. *In the test procedure phase, the vehicle shall be put through the snap-idle cycle three times.*

4. *The opacity shall be measured during the preconditioning and test phases with a smokemeter and shall be recorded continuously on the chart recorder during each snap-idle cycle. The maximum instantaneous value recorded by the chart recorder shall be the opacity reading.*

5. *The test opacity to determine the compliance with (A)1. and (A)2. above shall be the average of the two meter readings with the least difference in opacity values. If all three readings have successive equivalent differences between them, the test opacity shall be the average of the three readings.*

NOTE: Authority Cited: Sections 39600, 39601, 43013, 43701(a), Health and Safety Code. Reference: Sections 39002, 39003, 39033, 43000, 43013, 43018, 43701(a), and 44011.6, Health and Safety Code.

§ 2194. Record Keeping Requirements.

(a) The owner of a vehicle subject to the requirements of this ~~subchapter~~ *chapter* shall record the following information when performing the smoke opacity testing:

(1) The brand name and model of the opacity meter.

(2) The brand name and model of the strip chart recorder, *if an SAE J1243 type smoke meter is employed.*

(3) The dates of last calibration of the opacity meter and chart recorder.

(4) The name of the smoke meter operator who conducted the test.

(5) The name and address of the contracted smoke test facility or vehicle repair facility that conducted the test (if applicable).

(6) The applicable smoke opacity standard for the tested vehicle.

(7) Vehicle identification number, vehicle's engine year, engine make, and engine model, and test date. Fleet-designated vehicle identification numbers are also acceptable.

(8) The initial smoke test opacity levels (for three successive test readings).

(9) An indication of whether the vehicle passed or failed the initial smoke test.

(10) The post-repair test date.

(11) The post-repair smoke test opacity levels (for three successive test readings).

(12) An indication of whether the vehicle passed or failed the post-repair smoke test.

(13) For vehicles that have failed the smoke test and have been repaired, the vehicle repair information specified in section 2186(a), Title 13, California Code of Regulations.

NOTE: Authority Cited: Sections 39600, 39601, and 43701(a), Health and Safety Code. Reference: Sections 39002, 39003, 39033, 43000, 43018, 43701(a), and 44011.6, Health and Safety Code.

Attachment B

**Section-by-Section Explanation to
Title 13, California Code of Regulations
Sections 2180-2194**

ATTACHMENT B

Section-by-Section Explanation of Proposed Amendments to Title 13, California Code of Regulations, Sections 2180-2194

Note: The following summary explains the need for the various proposed amendments to the regulations pertaining to the Heavy-Duty Vehicle Inspection Program (HDVIP) and the Periodic Smoke Inspection Program (PSIP). The text of the proposed amendments is set forth in Attachment A. Some proposed amendments represent a change in regulatory policy while others simply nonsubstantive improvements or clarifications to the existing regulatory text. The first type is identified as "Policy change," and the latter as "Non-policy change." One area of non-policy changes is the addition of headings for various subsections and a reorganization of some provisions to make the regulations more user-friendly. Most of these changes are not separately discussed below. Subsection references are to the proposed new letters and numbers.

Proposed HDVIP Amendments

Sections in Title 13, California Code of Regulations

Section 2180. Applicability

(a) *Non-policy Change.* Since there is only one item in this section, there is no need to label it "(a)."

Section 2180.1 Definitions

(a)(1)& (2) *Policy change.* The terms "post-repair inspection" and "post-repair test," previously defined in (a)(21) and (22), have been modified to begin with "ARB," to make clear the term describes only tests and inspections conducted by ARB inspectors. The terms are used in section 2186(b)&(c); the inspection or test may optionally be used as a demonstration of correction by a cited party, and may be required by the ARB where inadequate information is supplied or there is a second violation on a truck or bus within a year. Staff's practice has been that these terms only apply to tests conducted by ARB inspectors. Note that in most circumstances, private tests and inspections will serve as part of the demonstration of correction. (section 2186(a)(3)&(4).)

(a)(3) *Non-policy change.* Staff proposes deletion of the term "reduced" in order to clarify the definition of "basic penalty." The original intent in defining the "basic penalty" as the "reduced" civil penalty of $500 was to acknowledge that the $500 penalty was reduced from the potential tutory maximum of $1500 under Health and Safety Code section 44011.6(h). Howe , this may have been nfusing to some parties. There is no change to the original approach — the monetary penalty for a first level citation (other than for a school bus) is the sum of two penalties: (1) a fixed non-reducible $300, plus (2) the basic $500, for a total of $800. The $500 portion can be waived if the citation is cleared within the allotted time period.

~~(2)~~ *Policy change.* The definition of "certification level" is no longer needed since all references to the term in the regulations are being deleted. See the discussion of section 2182(a).

(4) *Non-policy change.* The definition of "citation" has been clarified to reflect the fact that the citation is always to be issued to the owner rather than the operator of a noncomplying heavy-duty vehicle.

(5) *Non-policy change.* The original language has been made more precise.

(6) *Policy change.* Since the requirements in section 2186(a) for a demonstration of correction have been expanded, the definition of "demonstration of correction" is changed to refer to the documents required in section 2186(a); this includes situations where an owner or operator elects to conduct his/her own repairs. Although not expressly covered by the former definition, it has been ARB policy to accept owner conducted repairs in a demonstration of correction.

(9) *Non-policy change.* The readability of the definition has been improved.

(11) *Policy change.* The definition for a fleet has been modified to include two or more vehicles, aligning with the definition in the PSI program. This should have little practical significance.

~~(11)~~ *Non-policy change.* The definition for "full power position" is deleted because the term is no longer used in the regulations.

(12) *Non-policy change.* The definition of "heavy-duty vehicle" has been conformed to the definition in section 1900(a)(6), Title 13, California Code of Regulations.

(14) *Non-policy change.* Unnecessary words have been deleted.

(15) *Non-Policy change.* The definition of an "inspector" has been broadened to reflect that, with the adoption of the PSI program, an inspector is likely to have the additional responsibility of enforcing the PSI program regulations, sections 2190-4.

(16) *Non-policy change.* The definition of "issuance" has been made more precise.

(17) *Non-policy change.* The amendment simplifies the existing language by deleting the reference to the ultimate disposition of "minimum penalty" funds in the Diesel Emission Reduction Fund. It is not necessary to specify the end use of the deposited money since it is already specified in Health and Safety Code section 44011.6(*l*). The amendments also reflect the relettering of former section 44011.6(h) of the Health and Safety Code.

(18) *Policy change.* A definition of "notice of violation" has been added in connection with the new section 2185(b) provisions authorizing issuance of a notice of violation in lieu of a citation for a pre-1991 model diesel engine on the basis of a measured smoke opacity exceeding 55 percent but not exceeding 69 percent.

(21) *Policy change.* The definition of "owner" has been revised. The amendments clarify that an "owner," within the context of the HDVIP, can be the person or entity (other than the registered owner) that is shown to be legally responsible for the maintenance of the vehicle/engine. For example, when a citation is issued for a vehicle which is leased under terms that make the lessee responsible for the maintenance of the vehicle, the lessee will be treated as the owner if the lessor demonstrates the lessee's responsibility. This reflects the staff's practice under the original language. In addition, the amendments reflect the fact that trucks operated in California may be registered in provinces or other countries.

In addition, new language provides that the person identified as the owner on the registration document carried on a vehicle is presumed to be the owner unless that person demonstrates that another person is the owner. This avoids the burdensome need to present at the administrative hearing additional evidence of ownership of trucks registered in other states or countries.

~~(21)~~ & ~~(22)~~ *Non-policy change.* Revised definitions of these terms are in new (a)(1) and (2).

(24) *Policy change.* Since the proposed HDVIP regulations will now be referencing the SAE J1667 smoke test procedure, it is necessary to add a definition for SAE J1667 to clearly identify the procedure being designated.

(26) *Non-policy change.* Since the HDVIP will now be incorporating the SAE J1667 test procedure, the term "smokemeter" is being re-defined to require that it be designed in accordance with the SAE J1667 test procedure.

~~(27)~~ *Non-policy change.* The definition for "snap-idle" is deleted because the term is no longer used in the regulations.

~~(29)~~ *Non-policy change.* The definition for "test opacity" is no longer needed since the term is no longer used in the regulations.

~~(30)~~ *Non-policy change.* The definition of "test procedure" is deleted because the term is no longer used in the limited sense of referring only to the preconditioning sequence and smoke measurement process.

Section 2181. Responsibilities During Inspection Procedure.

(a) *Non-policy change.* The term "powered" has been added for clarification.

(a)(5) *Non-policy change.* Since the adopted SAE J1667 smoke test procedure does not require the use of a strip chart recorder, all references to a strip chart recorder are being deleted. Instead of signing the strip chart to acknowledge the test, the vehicle driver would now sign the smokemeter's test report printout.

(b) *Non-policy change.* The term "powered" has been added for clarification.

(c)(2) *Non-policy change.* References to section 2182 have been changed to reflect the proposed amendments to that section.

(c)(3) *Policy change.* A change is made to reflect the new "notice of violation" mechanism.

(c)(4) *Policy change.* New language directs the inspector to issue a notice of violation in lieu of a citation for a pre-1991 model diesel engine on the basis of a measured smoke opacity exceeding 55 percent but not exceeding 69 percent, except where a notice of violation or citation has been issued for the vehicle in the preceding 12 months. This new mechanism is described in the proposed amendments to section 2185(b).

(c) (5) *Policy change.* Staff proposes that the provisions on missing emission control labels be modified to require that the identification engine label be replaced (in order to determines the engine's serial number or identification) upon written notification by the ARB, instead of merely requiring that the information be provided to the ARB. This revised approach will facilitate ARB's efforts to properly identify vehicles in the field and limit computerized cross-checks to determine the status of the vehicle (i.e. whether or not any previous warnings were issued and whether the information was submitted.) Proposed new language distributed with the notice for the September 11, 1997 workshop has been revised to be consistent with the modified language in section 2182(c).

Section 2182 Heavy-Duty Vehicle Smoke Opacity Standards and Test Procedures; Excessive Smoke

2182 *Non-policy change.* The title to this section has been changed to be more informative by reflecting that the section also covers the smoke opacity standards and identifies what constitutes excessive smoke.

(a) *Non-policy change.* In order to improve the organization of section 2182, former subsections (a) and (b) have been identified as subsections (a)(1) and (a)(2), as they both establish smoke opacity standards.

(a) *Policy change.* The revisions reflect the changes to the opacity standards proposed by staff. The applicable standard for an engine will no longer be tied to an engine's federal smoke certification level (or the model year of the vehicle); instead, it will be based only on the model year of the engine. The 40 percent opacity standard will be applicable to 1991 and subsequent model-year engines, and the 55 percent opacity standard will apply to all pre-1991 model-year engines. This will simplify the standards and make them more straightforward.

1991 model-year cutoff for 40 percent standard. In the original regulations, all 1974 and subsequent model-year vehicles with federal peak smoke engine certification levels lower than 35 percent were subject to a 40 percent opacity standard; all others were subject to the 55 percent opacity standard. However, section 2185(b) (which is being deleted because it is no longer needed) provided that the only vehicles subject to a civil penalty for failing the 40 percent standard during the first year of the program were 1991 and subsequent model-year vehicles, and this was extended by the Executive Officer. In effect, this meant that all pre-1991 model-year vehicles were subject to a 55 percent standard. In conjunction with eliminating the references to federal certification peak opacity levels, the amendments make the pre-1991 model year cut-off permanent. Staff expects that this will have only a minor effect on passage rates in practice, since most pre-1991 engines that have failed the 40 percent opacity standard during roadside inspections have had opacity levels well in excess of 55 percent.

Elimination of references to federal certification level. This removes an element of complexity from the regulations that for three basic reasons is no longer needed. First, as noted above, all pre-1991 model-year engines will automatically be subject to the 55 percent opacity standard. Second, since the 1994 model year (the 1991 model year for urban bus engines), all heavy-duty diesel-fueled engines have had to certify to a 0.1 gr/bhp-hr particulate standard. Certification to this low particulate standard assures that the federal certification peak smoke opacity levels for these engines will uniformly be well below 35 percent, eliminating the need to account for higher federal certification smoke opacity levels from these late-model engines. And third, for the remaining 1991-1993 model-year engine families, there is less of a need for automatic exemptions based on the federal certification peak opacity levels because of the designation of SAE J1667 in place of SAE J1243. The SAE J1667 type smokemeter reads, on average, 5 to 10 percent opacity points less for mechanical and electronic engines, respectively, compared to SAE J1243 smokemeters.

References to model-year of the engine. The original standards referred to the model-year of the vehicle, even though the model-year of the engine is determinative of the applicable certification emission standards. The proposed amendments refer only to the model-year of the engine.

Also see the discussion in Section III.C. and D. of the Staff Report on the effect of the 40 percent and 55 percent opacity standards when the SAE J1667 test procedure is used.

(b) *Non-policy change.* In order to improve the organization of section 2182, the exemption provisions in (c), (d) and (f) have been consolidated into (b)(1),(2) and (3).

(b)(1) *Non-policy change.* Provisions have been clarified and unnecessary language has been eliminated without substantive change. The allowance of exemptions, when warranted, will continue.

(b)(2) *Non-policy change.* Provisions have been clarified and unnecessary language eliminated without substantive change. The allowance of exemptions, when warranted, will continue.

(b)(3) *Non-policy change.* Since an engine qualifying for an exemption under the preexisting provisions would qualify under the amendments, language is added "grandfathering in" exemptions that were issued and in effect as of January 1, 1996.

(b)(4) *Policy change.* (Previously subsection (f)). The references to peak opacity certification levels are no longer relevant and have been deleted. Provisions on notifications from engine manufacturers regarding newly-certified engines that qualify for exemptions have been deleted because 1997 and subsequent model-year engines certified to the 0.1 grams per brake horsepower hour particulate standard should not smoke. However, provisions referring to the need for the manufacturer to supply the ARB with the pertinent test data when seeking an exemption are still necessary and are being retained, with various clarifications.

(c) *Policy change.* (Previously subsection.(e).) As stated in the discussion of section 2181(c)(4), staff is proposing that the requirements in former section 2182(c) be modified to require that the identification engine label be replaced (so that the engine's serial number or identification can be determined) upon written notification by the ARB, instead of merely requiring that the information be provided to the ARB. This revised approach will facilitate ARB's efforts to properly identify vehicles in the field and limit computerized cross-checks to determine the status of a vehicle being inspected (i.e. whether or not any previous warnings were issued and whether the information was submitted). Proposed new language distributed in connection with the September 11,.1997 workshop imposed a conclusive presumption that a vehicle is subject to the more stringent 40 percent opacity standard where the emissions label is not timely replaced. A subsequent proposed modification makes the presumption inapplicable if at the time of the subsequent test it is plainly evident from a visual inspection that the vehicle is powered by a pre-1991 engine. In such a case, application of the presumption is inappropriate.

(d) *Non-policy change.* Health and Safety Code section 44011.6(a), added by AB 1460 in 1996, expressly prohibits the use of a heavy-duty motor vehicle that emits excessive smoke. To facilitate enforcement of this statute, a new subsection would be added stating that a heavy-duty vehicle has excessive smoke if it fails to comply with the applicable smoke opacity standard.

(e) *Policy change.* (Previously subsections (g) and (h)). Per staff's basic proposal, language would be added stating that smoke opacity is to be determined in accordance with SAE J1667. Prior subsections (g) and (h), which specified the smoke opacity equipment and test procedure steps, would be deleted. By simply identifying the SAE J1667 procedures, specific testing details need not be specified in the regulation.

Section 2183. Inspection of the Emission Control System on a Heavy-Duty Vehicle

Non-policy change. Title of section revised to be more readable.

Section 2184. Refusal to Submit to Inspection Procedure.

(a) *Non-policy Change.* Since there is only one item in this section, there is no need to label it "(a)."

Section 2185 Civil Penalty Schedule.

(a)(1) *Non-policy change.* Unnecessary language is being deleted. These changes are also made in (a)(2) and (a)(3). Also, language is added to clarify that the minimum penalty does not apply where the owner or driver refuses to submit to the test procedure; otherwise there would be an incentive to make such a refusal.

(a)(2) *Non-policy change.* Language is added to clarify that where the owner or driver refuses to submit to an inspection for the first time, the penalty is the $300 minimum penalty plus the $500 basic penalty.

(b) *Policy change.* The former language has been deleted. It is no longer pertinent since vehicles with pre-1991 model-year engines will no longer be subject to the 40 percent opacity standard.

New language has been added providing for issuance of a notice of violation rather than a citation for a heavy-duty vehicle powered by a pre-1991 model-year diesel engine on the basis of a measured smoke opacity exceeding the 55 percent standard but not exceeding 69 percent, and no notice of violation or citation has been issued for the vehicle in the preceding 12 months. If the owner provides a demonstration of correction within 45 days from receipt of the notice of violation, the owner will not be subject to any penalty. If a demonstration of correction is not provided within that time period, a citation will be issued. If the cited vehicle has not been cited within the previous year, the owner will be subject to the $800 penalty; if the cited vehicle *has* been cited within the previous year, the owner will be subject to the $1800 penalty.

Where a pre-1991 engine inspected under the HDVIP has a measured opacity exceeding 55 percent but not exceeding 69 percent within one year of issuance of an NOV for which a timely demonstration of correction was issued, a citation will be issued and the penalty will be $800. If the opacity is measured within that range and a citation had been issued for the vehicle within the preceding year, a citation will be issued and the penalty will the $1800 — the penalty applicable for second citations within a year. This higher penalty would apply both for prior citations issued in the first instance, and prior citations issued after the owner failed to make timely repairs in response to an NOV.

These requirements are discussed in Section IV.C. of the Staff Report.

(c) *Non-policy change.* Clarifying language is substituted, without substantive effect.

(d) *Non-policy change.* Clarifying language has been added to make sure that existing policy is appropriately characterized.

(e) *Non-policy change.* Clarifying language is added, without substantive effect.

Section 2186. Demonstration of Correction and Post-Repair Test or Inspection.

(a)(1) &(2) *Non-policy change.* The original subsection (a) provisions on submittal of a demonstration of correction only covered documentation of repairs made at a repair facility, or fleet repair maintenance facility. However, it was ARB's practice to accept a receipt for parts if the owner conducted his or her own repairs outside a repair facility or fleet facility. The text has been clarified so that the original provisions only apply where the repair is made at a repair or fleet facility. A new subsection (a)(2) is added for owners who conduct their own repairs outside repair or fleet facilities; in this case the owner is to submit an itemized receipt for parts and a statement identifying the date and nature of the repairs made.

(a)(3) &(4) *Policy change.* The original regulations did not expressly require that, following repairs, a cited truck must be retested in order to determine whether the repairs are sufficient for the truck to meet the opacity standard. Proposed new language is added to require such a retest and submittal of the pertinent test report with a short declaration by the retester as part of the demonstration of correction. This is a particularly important element in the case of owners of heavy-duty vehicles that receive a notice of violation, since waiver of the normal penalties is dependent on assurance that there have been sufficient repairs to enable the vehicle to meet the applicable 55 percent opacity standard. Similarly, new language is added requiring that, where a citation is issued because of failure of a visual inspection, the demonstration of correction must include a declaration that the components identified in the citation have been reinspected and have been determined to be in good working order.

(b) *Non-policy change.* Clarifying change to more accurately describe the documents submitted when an owner uses the section (a) demonstration of correction option.

(c) *Non-policy change.* Clarifying change to note the term "inspection" is meant to mean a post-repair inspection.

Section 2187 Vehicles Removed from Service

(c) *Non-policy change.* The redundant phrase "fifteen calendar" is being deleted.

Section 2188 Contesting a Citation

Non-policy change. New section 2188 is being added so that a person reviewing only the HDVIP regulations would be made aware that a citation can be contested under the established administrative hearing process in sections 60075.1 et seq., title 17, California Code of Regulations. Staff expects that the Board will consider amendments to the administrative hearing regulations at a hearing in Spring 1998.

PSIP Amendments

Sections in Title 13, California Code of Regulations

Section 2190. Vehicles Subject to the Periodic Smoke Inspection Requirements

2190 *Non-policy Change.* An appropriate title has been added. A revised date of applicability for these regulations of July 1, 1998 has also been specified — about six and a half months after the planned December 11, 1997 hearing. This much lead time will probably be needed to assure compliance with all of the rulemaking requirements. Identifying a specific effective date during the rulemaking process will give the regulated public more certainty.

(b) *Non-policy change.* It is not necessary to refer to the specific definition for "fleet" since the definition in section 2191(a) automatically applies.

Section 2191. Definitions.

(a)(2) *Non-policy change.* The definition for "inspector" is no longer needed since the revised definition of "inspector" in the HDVIP regulations (section 2180.1(a)(15)) will be identical and automatically applicable.

(a)(2) *Non-policy change.* The definition for "test opacity" has been made more precise.

(a)(4) *Non-policy change.* It is not necessary to define "test procedure" since the term's meaning in the regulations is evident.

Section 2192. Vehicle Inspection Responsibilities.

(a)(8) *Non-policy change.* This provision has been made more precise.

Section 2193. Smoke Opacity Inspection, Intervals, Standards, and Test Procedures.

(a) *Non-policy change.* Subsection (a), which lists the required periodic testing intervals for a fleet, has been broken up to enhance clarity; there are no substantive changes other than the new start date of July 1, 1998. Subsection (a) will apply to the initial phase-in requirements for vehicles that are subject to the PSI program as soon as it is up and running on July 1, 1998. Subsection (a)(1) covers the initial phase-in requirements for fleets of five or more vehicles, and (a)(2) applies to fleets of two to four vehicles. The last portion of former subsection (a), which addressed the phase-in for new fleets that become subject to the PSI program for the first time at some point *after* July 1, 1998, is relettered as subsection (b). Various provisions are made more precise.

(c) *Non-policy change.* Former section (b), which identifies the required annual testing schedule that applies after the initial phase-in period, has been revised for clarity. A heading has also be added.

(d) *Policy change.* A new subsection has been added providing a "rolling" exemption during the first four model years for 1994 and subsequent model-year engines. The exemption would last until January 1 of the calendar year that is four years after the model year of the engine. For example, a 1995 model-year engine would be exempt until January 1, 1999, and would be considered to have been acquired on that date. As discussed in the Staff Report, these vehicles are expected to have a failure rate of only about 1 percent due to the newness of the engines and stricter emission standards.

(e) *Policy change.* Former section (c), which specifies the standards and test procedures that apply to fleet testing, has been amended to reflect staff's proposed policy of identifying SAE J1667 as the applicable test procedure, referencing the proposed revised HDVIP standards, and allowing the limited use of the previously designated test procedures — based on SAE J1243 — during the first year of the program.

Section (e)(1) provides that the SAE J1667 test procedures and applicable standards specified in the HDVIP regulations will apply in the PSI program to the title 13 regulations as the regular testing procedures to follow, except as otherwise provided in subsection (e)(2).

Section (e)(2) allows the continued use of the old SAE J1243-type smokemeters for those fleets which do not have an operable SAE J1667 smokemeter, for one year, until July 1, 1999.

Section (e) (3) re-states the relevant aspects of the previous SAE J1243-based HDVIP procedures which fleets employing SAE J1243 type smokemeters must follow. Section (e)(3)(A) sets forth the original standards (making clear that all pre-1991 model-year engines are subject to the less stringent 55 percent opacity standard); section (e)(3)(B) re-specifies the original SAE J1243 smokemeter performance requirements, and section (e)(3)(C) re-specifies the original test procedures.

Section 2194. Record Keeping Requirements

(a)(2) *Non-policy change.* A conforming amendment has been made to acknowledge that the required strip chart information need only be maintained if an SAE J1243 smokemeter is employed.

Attachment C

Society of Automotive Engineers (SAE)
J1667 Recommended Practice

SAE The Engineering Society For Advancing Mobility Land Sea Air and Space INTERNATIONAL

400 Commonwealth Drive, Warrendale, PA 15096-0001

SURFACE VEHICLE RECOMMENDED PRACTICE

Submitted for recognition as an American National Standard

SAE J1667

Issued 1996-02

SNAP-ACCELERATION SMOKE TEST PROCEDURE FOR HEAVY-DUTY DIESEL POWERED VEHICLES

TABLE OF CONTENTS

1. *Scope*—This SAE Recommended Practice applies to vehicle exhaust smoke measurements made using the Snap-Acceleration test procedure. Because this is a non-moving vehicle test, this test can be conducted along the roadside, in a truck depot, a vehicle repair facility, or other test facilities. The test is intended to be used on heavy-duty trucks and buses powered by diesel engines. It is designed to be used in conjunction with smokemeters using the light extinction principle of smoke measurement.

This procedure describes how the snap-acceleration test is to be performed. It also gives specifications for the smokemeter and other test instrumentation and describes the algorithm for the measurement and quantification of the exhaust smoke produced during the test. Included are discussions of factors which influence snap-acceleration test results and methods to correct for these conditions. Unless otherwise noted, these correction methodologies are to be considered an integral part of the snap-acceleration test procedure.

1.1 Purpose—This document provides a procedure for assessing smoke emissions from in-use vehicles powered by heavy-duty diesel engines. Testing conducted in accordance with this procedure, in combination with reference smoke values, is intended to provide an indication of the state of maintenance and/or tampering of the engine and fuel system relative to the parameters which affect exhaust smoke. The procedure is expected to be of use to regulatory and enforcement authorities responsible for controlling smoke emissions from heavy-duty diesel-powered vehicles, and to heavy-duty vehicle maintenance and repair facilities. However, the procedure as written does not replicate the federal engine certification smoke cycle, and is intended to identify gross emitters. Regulatory agencies using this procedure must establish pass/fail criteria since SAE by-laws prohibit assignment of such criteria.

2. *References*

2.1 Applicable Documents—The following publications form a part of this specification to the extent specified herein. Unless otherwise specified, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1349—Engine Power Test Code—Spark Ignition and Compression Ignition—Net Power Rating
SAE J1995—Engine Power Test Code—Spark Ignition and Compression Ignition—Gross Power Rating

2.2 Related Publications—The following publications are provided for information purposes only and are not a required part of this document.

2.2.1 SAE Publications—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J255a—Diesel Engine Smoke Measurement
SAE J1243—Diesel Emission Production Audit Test Procedure

2.2.2 ISO Publication—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ISO CD 11614—Apparatus for the Measurement of the Opacity of the Light Absorption Coefficient of Exhaust Gas from Internal Combustion Engines

2.2.3 Federal Publication—Available from The Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Code of Federal Regulations (CFR), Title 40, Part 86, Subpart I—Emission Regulation for New Diesel Heavy-Duty Engines: Smoke Exhaust Test Procedure

2.2.4 OTHER

Procedures for Demonstrating Correlation Among Smokemeters

3. Definitions

3.1 **Diesel Smoke**—Particles, including aerosols, suspended in the exhaust stream of a diesel engine which absorb, reflect, or refract light.

3.2 **Transmittance (T)**—The fraction of light transmitted from a source which reaches a light detector.

3.3 **Opacity (N)**—The percentage of light transmitted from a source which is prevented from reaching a light detector. See Equation 1.

$$\text{Opacity \%} = 100 * (1 - \text{Transmittance}) \qquad \text{(Eq.1)}$$

3.4 **Effective Optical Path Length (L) or (EOPL)**—The length of the smoke obscured optical path between the smokemeter light source and detector. Note that portions of the total light source to detector path length which are not smoke obscured do not contribute to the effective optical path length.

3.5 **Smoke Density (K)**—(also known as "Light Extinction Coefficient" and "Light Absorption Coefficient") A fundamental means of quantifying the ability of a smoke plume or smoke containing gas sample to obscure light. By convention, smoke density is expressed on a per meter basis (m^{-1}). The smoke density is a function of the number of smoke particles per unit gas volume, the size distribution of the smoke particles, and the light absorption and scattering properties of the particles. In the absence of blue or white smoke, the size distribution and the light absorption/scattering properties are similar for all diesel exhaust gas samples and the smoke density is primarily a function of the smoke particle density.

3.6 **Beer-Lambert Law**—A mathematical equation describing the physical relationships between the smoke density (K) and the smoke parameters of transmittance (T), and effective optical path length (L). Because smoke density (K) cannot be measured directly, the Beer-Lambert equation is used to calculate (K), when opacity (N) and EOPL (L) are known.

3.7 **Smoke Opacimeter**—A type of smokemeter designed to measure the opacity of a plume or sample of smoke by means of a light extinction principle.

3.8 **Full-Flow End-of-Line Smokemeter**—A smokemeter which measures the opacity of the full exhaust plume as it exits the tailpipe. The light source and detector for this type of smokemeter are located on opposite sides of the smoke plume and in close proximity to the open end of the tailpipe. When applying this type of smokemeter, the effective optical path length is a function of the tailpipe design.

3.9 **Sampling Type Smokemeter (Also called Partial Flow Smokemeter)**—A smokemeter which continually samples a representative portion of the total exhaust flow and directs it to a measurement cell. With this type of smokemeter, the effective optical path length is a function of the smokemeter design.

3.10 **Smokemeter Measurement Zone**—The effective length between the smokemeter light source and light detector through which exhaust gases pass and interact with the smokemeter light beam.

3.11 **Smokemeter Response Time**—See 6.3 and Appendix A.

3.12 Smokemeter Linearity—A measure of the maximum absolute deviation of values measured by the smokemeter from the reference values.

4. Special Notes and Conventions

4.1 The term smokemeter is a broad term which applies to all smoke-measuring devices regardless of the smoke-sensing technique employed. Throughout this document, the term smokemeter will refer only to opacimeter type smokemeters.

4.2 To fully describe the light obscuration properties of a smoke sample (i.e., smoke density), opacity (N) must always be associated with an EOPL. Whenever specific smoke opacity values are referenced in this document, the associated effective optical path length is understood to be 0.127 m (5 in).

5. *Snap-Acceleration Test*—The complete Snap-Acceleration process consists of five phases. These phases are:

a. Vehicle Preparation and Safety Check
b. Test Preparation and Equipment Set-up
c. Driver Familiarization and Vehicle Preconditioning
d. Execution of the Snap-Acceleration Test
e. Calculation and Reporting of Final Results

5.1 **Vehicle Preparation and Safety Check**—Prior to conducting the snap-acceleration test, the following items must be completed:

a. If the vehicle is equipped with a manual transmission, the transmission must be placed in neutral and the clutch must be released.

   If the vehicle is equipped with an automatic transmission, the transmission must be placed in the park position, if available, or otherwise in the neutral position.

b. The vehicle wheels must be chocked or the vehicle must be otherwise restrained to prevent the vehicle from moving during the testing.

c. Vehicle air conditioning should be turned off.

d. If the engine is equipped with an engine brake, it must be deactivated during the snap-acceleration testing.

e. All devices installed on the engine or vehicle which alter the normal acceleration characteristics of the engine and have the effect of temporarily lowering snap-acceleration test results, or preventing the test from being successfully completed, shall be deactivated prior to testing.

f. Verify the speed-limiting capability of the engine governor using the following procedure:

   With the engine at low idle, slowly depress the engine throttle and allow the engine speed to gradually increase toward its maximum governed high idle speed. As the engine speed increases, carefully note any visual or audible indications that the engine or vehicle may be of questionable soundness. If there are no indications of problems, allow the engine speed to increase to the point that it is possible to verify that the speed-limiting capability of the governor is functioning. Should there be any indication that the speed-limiting capability of the governor is not functioning, or that potential engine damage, or unsafe conditions for personnel or equipment may occur, the throttle should immediately be released and the snap-acceleration testing of the vehicle shall be aborted.

g. The vehicle should be inspected for exhaust leaks. Severe leaks in the system may cause the introduction of air into the exhaust stream which may cause erroneously low test results.

h. Users must be cautioned regarding the observance of blue or white smoke in the exhaust. Blue smoke can be an indicator of unburned hydrocarbons (possible oil burning or malfunctioning nozzle), and white smoke can be an indicator of water vapor (possible internal coolant leaking conditions).

5.2 Test Preparation and Equipment Set-up

5.2.1 AMBIENT AIR TEST CONDITIONS—Ambient air conditions can affect snap-acceleration smoke test results. To ensure reliable results, the correction factors in Appendix B should be applied to snap-acceleration testing results to account for normal changes in ambient conditions. However, these correction factors must be applied under the following conditions.

a. Altitude—Greater than 457 m (1500 ft) above sea level.

b. Air Temperature—Above or below the range of 2 to 30 °C (36 to 86 °F).

c. Wind—Excessively windy conditions should be avoided. Winds are excessive if they disturb the size, shape, or location of the vehicle exhaust plume in the region where exhaust samples are drawn or where the smoke plume is measured. The effect of wind may be eliminated or reduced by locating the vehicle in a wind-sheltered area or by using measuring equipment designs which preclude wind effects on the smoke in the measuring or sampling zones.

d. Dry Air Density—If the correction factors referenced in Appendix B are used, the useful range of dry air densities are: 0.908 to 1.235 kg/m^3 (0.0567 to 0.0771 lbm/ft^3). This range of dry air densities is based on air densities experienced during ambient conditions testing.

e. Humidity—No visible humidity (including fog, rain, and snow) in the region where exhaust samples are drawn or the smoke plume is measured. Some equipment designs preclude the effects of these conditions.

5.2.2 SMOKEMETER INSTALLATION—The smokemeter and other test equipment used for snap-acceleration tests shall meet the specifications of 6.1 through 6.5. The general installation procedures specified by the smokemeter manufacturer shall be followed when preparing to test a vehicle.

In addition, these special installation procedures shall be followed:

a. If the test results are to be reported in units of smoke opacity, the rated power of the engine should be determined. The rated power is needed to define the standard effective optical path length used to correct the as-measured smoke opacity to standard conditions as described in Appendix C. The rated power should be available from the tune-up label fixed to the engine or from literature supplied to the owner by the engine manufacturer. In some cases, particularly under roadside test conditions, it may not be possible to readily determine the rated engine power. In these cases, it is recommended that the OD of the vehicle tailpipe section be determined and used as the standard effective optical path length for the purposes of the Beer-Lambert corrections described in Appendix C. If the rated engine power becomes available after the test is run, the test result should be recorrected as necessary using Equation C3 and the appropriate standard effective optical path length from Table C1.

Sampling in or immediately downstream of bends such as curved stack outlets in the exhaust pipe may cause some variability between individual Snap-Acceleration cycle readings.

b. For Full Flow End-of-Line Type Smokemeters—The axis of the smokemeter light beam shall be perpendicular to the axis of the exhaust flow. The centerline of the light beam axis should be located as close as possible, but in no case further than 7 cm (2.76 in) from the exhaust outlet. Appendix D provides additional guidance for smokemeter replacement.

Determine the effective optical path length used to make the smoke measurements. For straight tailpipes of circular cross section, the effective optical path length is equal to the tailpipe ID, and for tubing construction can be reasonably approximated by the tailpipe OD. Appendix D provides guidance for determining the as-measured effective optical path length when irregular tailpipe configurations are encountered. The as-measured effective optical path length is required to convert measured smoke values to standard corrected smoke values using the procedures described in Appendix C.

c. For Sampling Type Smokemeters—The probe of the sampling type smokemeter shall be inserted into the exhaust tailpipe with the open end facing upstream and into the exhaust flow.

The clearance between the inside edge of the open end of the sample probe and the tailpipe wall must be at least 5 mm (0.197 in).

Only the probe and sampling pipe, or tubing, specified by the manufacturer of the smokemeter shall be used for the smoke sampling. Manufacturer's recommendations regarding the length of the sample line shall be adhered to.

d. Multiple Exhaust Outlets—When testing vehicles equipped with multiple exhaust outlets, such as dual exhaust systems originating from a single manifold or single pipe, it is normally not necessary to measure the smoke from each exhaust outlet. The following approach is suggested.

If there is no discernible difference in the exhaust smoke exiting from each multiple exhaust outlet, the smoke should be measured from the exhaust outlet that provides the most convenient meter installation. A visual observation of one or more preliminary snap-acceleration test cycles should be sufficient to make this determination.

Should there be a discernible difference in the smoke exiting from the multiple exhaust outlets, install the smokemeter and conduct the snap-acceleration test on the exhaust outlet that visually appears to have the highest smoke level.

5.2.3 A tachometer to measure the engine speed may be installed and calibrated per the manufacturer's recommendations. A tachometer provides useful data regarding idle RPM, maximum engine RPM, the time necessary for the operator to accelerate the engine from idle to maximum RPM, and the time the engine speed was held at maximum RPM. This information helps to ensure repeatability between test cycles.

5.3 Driver Familiarization and Vehicle Preconditioning

5.3.1 Prior to the preconditioning test, the vehicle should be operated under load for at least 15 min to ensure that the engine is warmed-up. Alternatively, vehicle water and oil temperature gages may be checked to verify that the engine is within its normal operating temperature range.

5.3.2 SNAP-ACCELERATION CYCLE—The vehicle operator shall be instructed on the proper execution of the snap-acceleration test sequence. It is of critical importance that the vehicle operator fully understand the proper movement of the vehicle throttle during the testing.

With the vehicle conditioned as in 5.1 and with the engine warmed-up and at low idle speed:

a. The operator shall move the throttle to the fully open position as rapidly as possible.

b. The operator shall hold the throttle in the fully open position until the time the engine reaches its maximum governed speed, plus an additional 1 to 4 s.

c. Upon completion of the 1 to 4 s with the engine at its maximum governed speed, the operator shall release the throttle and allow the engine to return to the low idle speed.

d. Once the engine reaches its low idle speed, the operator shall allow the engine to remain at idle for a minimum of 5 s, but no longer than 45 s, before initiating the next snap-acceleration test cycle.

   The time period at low idle allows the engine's turbocharger (if so equipped) to decelerate to its normal speed at engine idle. This helps to reduce the smoke variability between snap-acceleration cycles.

e. Steps (a) through (d) shall be repeated as necessary to complete the preliminary snap-acceleration cycles and the snap-acceleration test cycles described in 5.3.3 and 5.4.2.

5.3.3 PRELIMINARY SNAP-ACCELERATION TEST CYCLES—The vehicle shall receive at least three preliminary snap-acceleration test cycles using the sequence described in 5.3.2. The preliminary cycles allow the vehicle operator to become familiar with the proper throttle movement, and also remove any loose soot which may have accumulated in the vehicle exhaust system during prior operation.

If smoke measurements are made during the preliminary cycles, the preliminary cycles can also provide the opportunity to check for proper operation of the smoke measurement system, and to check if the test validation criteria of 5.4.4 can be met. In this case, the data-processing unit and the smokemeter zero and full scale should first be set according to 5.4.1 and 5.4.2.

5.4 Execution of the Snap-Acceleration Test

5.4.1 DATA PROCESSING UNIT SET-UP—Before snap-acceleration testing can proceed, the smokemeter data processing unit must be properly set up. The operating instructions supplied by the processing unit manufacturer should be consulted for specific set-up procedures; however, the following functional steps must be accomplished.

a. If a multi-mode test system is used, the appropriate mode for snap-acceleration testing must be selected.

b. The desired smoke output units (opacity or smoke density) must be selected.

c. If the Beer-Lambert corrections as described in Appendix C are to be performed within the data-processing unit, values must be supplied for the standard and as-measured effective optical path lengths if opacity output is desired and for the as-measured effective optical path lengths if smoke density output is desired. Appendices C and D provide guidance in determining these input values.

d. If a red LED smokemeter light source is used and light source wavelength corrections are to be performed within the data-processing unit, the appropriate selections must be made to trigger these calculations (see Appendix C).

e. If the ambient condition corrections described in Appendix B are to be performed automatically by the data-processing unit, the appropriate ambient parameters must be input.

f. Any additional test identification information consistent with the needs of the test program and capabilities of the data-processing unit should be supplied at this time. Normally this would include the test date, test operator, vehicle identification, and other such information.

5.4.2 SMOKEMETER ZERO AND FULL SCALE—Prior to conducting smoke measurements, the zero and full scale readings of the smokemeter shall be verified. (Some meter systems may automatically perform the zero and full scale checks. For other meters, this sequence will need to be done manually.) Should optional recording devices be part of the test set-up, this equipment should also be checked for proper operation and calibration.

a. Smokemeter Warm-up—Prior to any zero and/or full-scale checks or adjustments, the smokemeter shall be warmed up and stabilized according to the manufacturer's recommendations. If the smokemeter is equipped with a purge air system to prevent sooting of the meter optics, this system should also be activated and adjusted according to the manufacturer's recommendations.

b. Smokemeter Zero—With the smokemeter in the Opacity readout mode, and with no blockage of the smokemeter light beam, adjust the readout to display 0.0% ± 1.0% opacity.

c. Smokemeter Full Scale—With the smokemeter in the Opacity readout mode, and all light prevented from reaching the detector, adjust the readout of the smokemeter to display 100.0% ± 1.0% opacity.

NOTE—For Smokemeter readouts in units of Smoke Density (K).

Smoke density (K) is a calculation based upon opacity and EOPL. The opacity scale offers two truly definable calibration points, namely 0% opacity and 100% opacity. The upper end of the smoke density scale is infinite, which makes this point on the K scale undefined. Because of this, the preferred method to set the zero and full scale of the meter when measuring in either smoke density (K) or opacity (N) units is to set the meter to the opacity readout mode and make the zero and full-scale adjustments as described in 5.4.2 (a) to (c). The smoke density would then be correctly calculated based upon the measured opacity and, of course, the EOPL, when the meter is returned to the smoke density readout mode for testing.

However, if this technique is not possible, it is acceptable to set the zero and span of the smokemeter in units of smoke density (K) with the use of a neutral density filter of known value. Should this be the case, the smokemeter zero and span shall be set as follows:

d. Smokemeter Zero—With the smokemeter in the Smoke Density (K) readout mode, and with no blockage of the smokemeter light beam, adjust the readout to display 0.00 m^{-1} ± 0.10 m^{-1}.

e. Smokemeter Span (If required by the smokemeter manufacturer)—With the smokemeter in the Smoke Density (K) readout mode, place a neutral density filter of known value between the light emitter and detector. The neutral density filter shall meet the accuracy requirements of 6.2.10 and have a known nominal value in the range of 1.5 to 5.5 m^{-1}. Adjust the smokemeter readout to display the filter nominal value, ±0.10 m^{-1}.

NOTE—Neutral density calibration filters are precision devices and can easily be damaged during use. Handling should be minimized and, when required, should be done with care to avoid scratching or dirtying of the filter.

5.4.3 SNAP-ACCELERATION TEST CYCLES—Within 2 min of the execution of the preliminary snap-acceleration cycles, conduct three snap-acceleration test cycles, actuating the vehicle throttle in the manner and sequence described in 5.3.2 (a to e).

Determine the corrected maximum 0.5 s average smoke values for each of the three snap-acceleration cycles using the smoke data processing algorithms described in Appendices A and C.

At the conclusion of the test sequence, and where needed as per manufacturer's recommendation, determine the degree of smokemeter zero shift by eliminating all exhaust from between the smokemeter light source and detector and noting the smokemeter display.

5.4.4 TEST VALIDATION CRITERIA—The test results from 5.4.3 shall be considered valid only after the following criteria have been met.

a The post-test smokemeter zero shift values shall not exceed:

(1) ±2.0% opacity—For smoke measurements made in opacity.

(2) ±0.15 m^{-1}—For smoke measurements made in smoke density (K).

b. The arithmetical difference between the highest and lowest corrected maximum 0.5 s average smoke values from the three test cycles shall not exceed:

(1) 5.0% opacity—For smoke measurements made in opacity.

(2) 0.50 m^{-1}—For smoke measurements made in smoke density (K).

5.4.5 INVALID TESTS—Should the smoke test data from 5.4.3 not meet the test validation criteria of 5.4.4, the following items should be checked as possible causes for the invalid test results:

a. If the engine did not meet the operating temperature requirements, run the engine/vehicle under load for at least 15 min or until the vehicle oil and water temperature gages indicate that normal engine operating temperatures have been achieved. Return to 5.2.2 (Smokemeter Installation) and repeat the test sequence.

b. If improper or inconsistent application of the vehicle throttle is suspected, re-instruct the vehicle operator as to the proper execution of the snap-acceleration test, especially the movement of the vehicle throttle, as detailed in 5.3.2. Continue on with the procedure at this point and repeat the preliminary test cycles and the snap-acceleration test sequence while observing the vehicle operator.

c. Check the smokemeter, its installation on the tailpipe, and any support instrumentation for possible malfunctions. Correct as necessary and then return to 5.3.3 (Preliminary Snap-Acceleration Test Cycles), and repeat the test sequence.

d. If the post-test smokemeter zero check was exceeded due to positive zero drift, the probable cause is soot accumulation on the smokemeter optics. It is recommended that the snap-acceleration test sequence be repeated and while doing so, the smokemeter zero may be readjusted during the low idle period between each of the snap-acceleration test cycles. If the measured low idle smoke level of the vehicle is less than 2.0% opacity or 0.20 m^{-1} smoke density, it is permissible to re-zero the meter while it remains exposed to the vehicle exhaust. If the idle smoke level exceeds these limits, it is necessary to discontinue exposure to exhaust before rezeroing the meter.

   It is not necessary to complete an invalid test before employing the rezeroing technique discussed previously. If comparison of the low idle smoke readings shows an increasing trend from one test cycle to the next, sooting of meter optics can be suspected and the rezeroing technique can immediately be used.

   If it is not possible to rezero the meter, the meter optics should be cleaned per the smokemeter manufacturer's recommended procedures and the test sequence should be repeated beginning at 5.3.3 (preliminary snap-acceleration test cycles). If zero drift and rezeroing difficulties persist, it is recommended that the meter purge air system (if so equipped) be checked for proper operation.

e. If the procedure has been repeated in accordance with the requirements stated in 5.4.5 (a to d), and the test results still cannot be obtained that conform with the test validation criteria, then it is likely that the engine is in need of service.

5.5 Calculation and Reporting of Final Test Result—If the validation criteria of 5.4.4 are met, the data shall be deemed valid and the test complete. The average of the corrected maximum 0.5 s average smoke values from the three snap-acceleration test cycles shall be computed and reported as the final test result. (See Appendix A.)

6. Test Instrumentation Specifications—This section provides specifications for the required and optional test equipment used in the snap-acceleration test.

6.1 General Requirements for the Smoke Measurement Equipment—The snap-acceleration smoke test requires the use of a smoke measurement and data-processing system which includes three functional units. These units may be integrated into a single component or provided as a system of interconnected components. The three functional units are:

a. A full-flow end-of-line or a sampling type smokemeter meeting the specifications of 6.2 through 6.4.

b. A data-processing unit capable of performing the functions described in Appendices A and C.

c. A printer and/or electronic storage medium to record and output the individual corrected maximum 0.5 s average smoke values from each snap-acceleration test cycle, and the final average snap-acceleration test result.

6.2 Specific Requirements for the Smoke Measurement Equipment

6.2.1 LINEARITY—±2% opacity or ±0.30 m^{-1} density.

6.2.2 ZERO DRIFT RATE—Not to exceed ±1% opacity/hour.

6.3 Instrument Response Time Requirements

6.3.1 OVERALL INSTRUMENT RESPONSE TIME REQUIREMENT—The overall instrument response time (t) shall be: 0.500 s ± 0.015 s. It is defined as the difference between the times when the output of the smokemeter reaches 10% and 90% of full scale when the opacity of the gas being measured is changed in less than 0.01 s. It shall include all the physical, electrical, and filter response times. Mathematically, it is represented by Equation 2. (See Appendix A for a more detailed methodology and an example calculation.)

$$t = SQRT\ (t_p^2 + t_e^2 + t_F^2) \qquad \text{(Eq.2)}$$

where:

t_p = The physical response time
t_e = The electrical response time
t_F = The filter response time

6.3.2 PHYSICAL RESPONSE TIME (t_p)—This is the difference between the times when the output of a rapid response receiver (with a response time of not more than 0.01 s) reaches 10% and 90% of the full deviation when the opacity of the gas being measured is changed in less than 0.1 s.

The physical response time is defined for the smokemeter only and excludes the probe and sample line. However, on some in-use smokemeter systems, the probe and sample line may significantly affect the overall response time of the system. If necessary, this shall be taken into account for any particular smokemeter system.

For full-flow type smokemeters, the response time is a function of the velocity of flow in the vehicle exhaust pipe and the path length across the detector (detector diameter). It can be assumed equal to a negligible 0.01 s. For sampling type smokemeters where the measuring zone is a straight section of pipe of uniform diameter, the physical response can be estimated by Equation 3:

$$t_p = 0.8 * V/Q \qquad \text{(Eq.3)}$$

where:

Q = The rate of flow of gas through the measuring zone
V = The volume of the measuring zone

For such instruments, the speed of the gas through the measuring zone shall not differ by more than 50% from the average speed over 90% of the length of the measuring zone.

For all smokemeters, if the physical response calculates greater than 0.2 s, then the response time shall be measured.

6.3.3 ELECTRICAL RESPONSE TIME (t_e)—It is defined as the time needed for the recorder output to go from 10% of the maximum scale to 90% of the maximum scale value when a fully opaque screen is placed in front of the photo cell in less than 0.01 s, or the LED is turned off. This is to include all of the effects of recorder output response time.

6.3.4 FILTER RESPONSE TIME (t_F)—Filtering of the smoke signal will be necessary on most smokemeters to achieve an overall response time of 0.500 s ± 0.015 s. Most smokemeters have a very fast electrical response time, but physical response times will vary from one device to the next depending on design and gas flow.

Appendix A specifies the recommended second-order digital filtering algorithm to be used.

6.3.5 DETERMINATION OF THE PEAK SMOKE VALUE—An algorithm in Appendix A shall be used to determine the reported peak exhaust smoke levels.

6.4 Smokemeter Light Source and Detector

6.4.1 LIGHT SOURCE—The light source shall be an incandescent lamp with a color temperature in the range of 2800 to 3250 °K, or a green light emitting diode (LED) with a spectral peak between 550 and 570 nm.

Alternatively, a red LED may be used provided that the appropriate light wavelength correction is made as described in Appendix C.

6.4.2 LIGHT DETECTOR—The light detector shall be a photocell or a photodiode (with a filter, if necessary). In the case of an incandescent light source, the detector shall have a peak spectral response in the range of 550 to 570 nm, and shall have a gradual reduction in response to values of less than 4% of the peak response value below 430 nm and above 680 nm.

6.4.3 The rays of the light beam shall be parallel within a tolerance of 3 degrees of the optical axis. The detector shall be designed such that it is not affected by direct or indirect light rays with an angle of incidence greater than 3 degrees to the optical axis.

6.4.4 Any method such as purge air which is used to protect the light source and detector from direct contact with exhaust soot shall be designed to minimize any unknown effect on the effective optical path length of the measured smoke (see C.5.1). For full-flow end-of-line smokemeters, the protection feature must not cause the smoke plume to be distorted by more than 0.5 cm. For sampling type smokemeters, the meter manufacturer must account for any effect of the protection feature in specifying the effective optical path length of the meter.

6.4.5 The sampling and digitization rate of the data processing units shall be at least 20 Hz (i.e., at least 10 data samples per 0.5 s interval). Additionally, the product of the data sampling time increment (seconds) and one half the data sample rate (Hz) rounded to the next higher integer value must be within the range of 0.500 to 0.510 s.

6.5 Specifications for Auxiliary Test Equipment

6.5.1 NEUTRAL DENSITY FILTERS—Any neutral density filter used in conjunction with smokemeter calibration, linearity measurements, or setting span shall have its value known to within 0.5% opacity or 0.04 m^{-1}. The filter's named value must be checked for accuracy at least yearly using a reference traceable to a national standard.

6.5.2 If altitude correction (i.e., the altitude is greater than 457 m (1500 ft)) then:

a. Equipment used to measure barometric pressure must be accurate within ±0.30 kPa (±0.089 in-Hg)

b. Ambient dry bulb temperature must be accurate within ±2 °C (±3.6 °F)

6.5.3 Measurement of the following parameters is optional; however, if measured, the specified accuracy requirements should be met:

a. Ambient Dry Bulb Temperature—±2 °C (±3.6 °F)
b. Dew Point Temperature—±2 °C (±3.6 °F)
c. Engine Speed—±100 rpm

6.5.4 OPTIONAL RECORDING DEVICES—A supplemental chart recorder or other collection media may be used provided that the device(s) does not affect the smoke measurement.

7. ***Smokemeter Maintenance and Calibration***—The smokemeter should be maintained and serviced per the manufacturer's recommendations. In addition to the zero and span adjustments to be made prior to each snap-acceleration test (5.4.2), the linearity of the meter response should be periodically checked as per manufacturer's recommendations in the range of measurement interest using neutral density filters meeting the requirements of 6.5.1. Non-linearities in excess of 2% opacity or 0.30 m^{-1} smoke density should be corrected prior to resuming testing with the meter.

PREPARED BY THE SAE HEAVY-DUTY IN-USE EMISSION STANDARDS COMMITTEE

APPENDIX A
SECOND-ORDER FILTER ALGORITHM USED TO CALCULATE A MAXIMUM 0.500 s AVERAGE SMOKE VALUE

A.1 *Introduction*—This appendix explains how to create and use the recommended Bessel low-pass digital filter algorithm in a smokemeter to filter out the high-frequency smoke readings which are produced during a snap-acceleration test. This appendix in particular describes the methodology used to design a low-pass second-order Bessel filter with a response time as needed for a particular smokemeter application. This appendix also describes the procedure for determining the final snap-acceleration test. Two example calculations detailing the selection of Bessel filter coefficients and their use are also provided in this appendix to illustrate the concepts more clearly.

The digital Bessel filter described in this appendix is a second-order (2-pole) low-pass digital filter algorithm. It is the recommended filter to be used for designing smokemeters with 0.500 s overall response times as required in 6.3. The Bessel filter type was chosen because it allows passage of all signals which do not change very much with time, but effectively blocks all signals with higher-frequency components. Its linear-phase characteristics also enable it to approximate a constant time delay over a limited frequency range. Transient waveforms can also be passed with minimal distortion when it is used as a running average type filter. A digital approach was chosen due to the relative ease of implementing a software algorithm in most smokemeters. However, analog Bessel filters using the appropriate electronic circuits may also be used.

A.2 *Definitions*

- B = Bessel parameter constant. It equals [Sqrt(5)−1]/2
- f_c = Bessel cutoff frequency used to control the filtered response
- t_e = Electrical response time of the smokemeter (seconds)
- t_F = Filter response time (seconds)
- t_{Fd} = Desired filter response time (seconds)
- t_p = Physical response time of the smokemeter (seconds)
- t_{10} = The test time when the output response to an input step response is equal to 10% of the step input
- t_{90} = The test time when the output response to an input step response is equal to 90% of the step input
- Δt = Time between two stored opacity values (i.e., sampling period (seconds))
- X_i = Bessel filter input at sample number (i)
- X_{i-1} = Bessel filter input at sample number (i−1)
- X_{i-2} = Bessel filter input at sample number (i−2)
- Y_i = Bessel filter output at sample number (i)
- Y_{i-1} = Bessel filter output at sample number (i−1)
- Y_{i-2} = Bessel filter output at sample number (i−2)

A.3 Designing a Bessel Low-Pass Filter—Designing the 0.500 s Bessel low-pass digital filter is a multistep process which may involve several iterative calculations to determine coefficients. This section provides a method for determining the desired amount of filtering for smokemeters with different electrical and physical response times, or different sample rates. Bessel filters can be designed to accommodate filter designs having response times ranging from 0.010 to 0.500 s, and digitization rates of 50 Hz and higher.

It is recommended that all Bessel filter calculations be performed in opacity units for the sake of consistency between smokemeters. If smokemeter output in units of density need to be reported, the Beer-Lambert law may be used to convert the final opacity results to density results, and perform any necessary stack size correction. This conversion should be done only after all Bessel filter equations have been performed due to the non-linearity of the Beer-Lambert law.

A.3.1 Calculating the Desired Filter Response Time (t_{Fd})—Prior to designing a digital Bessel filter, it is necessary to determine the physical response time (t_p) and the electrical response time (t_e) for the relevant smokemeter. These parameters are necessary in order to determine how much electronic filtering is necessary to achieve an overall 0.500 s response time. For some partial flow smokemeters this may require experimental data. For other smokemeters the procedures and equations in 6.3 may be used.

Once the values of t_p and t_e are known, the desired filter response time (t_{Fd}) can be determined by using Equation A1.

$$t_{Fd} = \mathrm{SQRT}\,[0.500^2 - (t_p^2 + t_e^2)] \qquad \text{(Eq.A1)}$$

A.3.2 Estimating Bessel Filter Cutoff Frequency (f_c)—The Bessel filter response time (t_F) is defined as the time in which the output signal (Y_i) reaches 10% (Y_{10}) and 90% (Y_{90}) of a full-scale input step (X_i) which occurs in less than 0.01 s. The difference in time between the 90% response (t_{90}) and the 10% response time (t_{10}) defines the response time (t_F). Thus,

$$(t_F) = (t_{90}) - (t_{10}) \qquad \text{(Eq.A2)}$$

For the filter to operate properly, the filter response time (t_F) should be within 1% of the desired response time (t_{Fd}), that is, $[(t_F) - (t_{Fd})] < [0.01 * (t_{Fd})]$.

To create a filter where t_F approximates t_{Fd}, the appropriate cutoff frequency (f_c) must be determined. This is an iterative process of choosing successively better values of (f_c) until $[(t_F) - (t_{Fd})] < [0.01 * (t_{Fd})]$.

The first step in the process is to calculate a first guess value for f_c using Equation A3.

$$f_c = \pi/(10 * t_{Fd}) \qquad \text{(Eq.A3)}$$

The values of B, Ω, C, and K are then calculated using Equation A4 through A7.

$$B = 0.618034 \qquad \text{(Eq.A4)}$$

$$\Omega = 1/[\tan(\pi * \Delta t * f_c)] \qquad \text{(Eq.A5)}$$

$$C = 1/[1 + \Omega * sqrt(3 * B) + B * \Omega^2] \quad \text{(Eq.A6)}$$

$$K = 2 * C * [B * \Omega^2 - 1] - 1 \quad \text{(Eq.A7)}$$

Δt = Time between two stored opacity values (i.e., sampling period (seconds)).

The values of K and C are then used in Equation A8 to calculate the Bessel filter response to the given step input. Because of the recursive nature of Equation A8, the values of X and Y listed as follows are used to begin the process.

$$Y_i = Y_{i-1} + C * [X_i + 2 * X_{i-1} + X_{i-2} - 4 * Y_{i-2}] + K * (Y_{i-1} - Y_{i-2}) \quad \text{(Eq.A8)}$$

where:

$X_i = 100$
$X_{i-1} = 0$
$X_{i-2} = 0$
$Y_{i-1} = 0$
$Y_{i-2} = 0$

As shown in the example (A.7.1), calculate Y_i for successive values of $X_i = 100$ until the value of Y_i has exceeded 90% of the step input (X_i). The difference in time between the 90% response (t_{90}) and the 10% response (t_{10}) defines the response time (t_F) for that value of (f_c). Since the data are digital, linear interpolation may be needed to precisely calculate t_{10} and t_{90}.

If the response time is not close enough to the desired response time {that is, if $[(t_F)-(t_{Fd})] > [0.01*(t_{Fd})]$}, then the iterative process must be repeated with a new value of (f_c). The variables (t_F) and (f_c) are approximately proportional to each other, so the new (f_c) should be selected based on the difference between (t_F) and (t_{Fd}) as shown in the example calculations (A.5.1).

A.4 Using the Bessel Filter Algorithm—The proper cutoff frequency (f_c) is the one that produces the desired filter response time (t_{Fd}). Once this frequency has been determined through the iterative process, the proper Bessel filter algorithm coefficients for Equation A4 through A7 are specified. Equation A8 and the coefficients can then be programmed into the smokemeter to produce the desired filter.

The Bessel filter equation (Equation A8) is recursive in nature. Thus, it needs some initial input values of X_{i-1} and X_{i-2} and initial output values Y_{i-1} and Y_{i-2} to get the algorithm started. These may be assumed to be 0% opacity. A detailed example calculation is shown in A.7.3.

A.5 Determining the Maximum 0.500 s Averaged Smoke Value—The maximum smoke value for a snap-acceleration test cycle (Y_{max}) is then selected from among the individual Y_i values computed using Equation A8 (after suitable Beer-Lambert and light source wavelength corrections are applied). This is the final test result for the test cycle and is used in combination with the results from the other snap-acceleration cycles in the test to determine a final snap-acceleration test result.

In equation form:

$$Y_{max} = \text{Maximum}\ (Y_i) \qquad \text{(Eq.A9)}$$

A.6 Determination of the Final Test Result—If the test validation criteria of 5.4.4 have been met, the final snap-acceleration test result shall be computed by taking the simple average of the three corrected maximum 0.500 s averaged smoke values obtained from the three snap-acceleration test cycles.

$$A = (Y_{max,1} + Y_{max,2} + Y_{max,3})/3 \qquad \text{(Eq.A10)}$$

A.7 Example of Incorporating a Bessel Filter Into a Smokemeter Design—This example illustrates how a full flow meter with a fast physical and electrical response time can implement the Bessel filter algorithm. The sample smokemeter has the following characteristics:

a. Physical Response Time = 0.020 s
b. Electrical Response Time = 0.010 s
c. Sampling Rate = 100 Hz
d. Sampling Period = 0.01 s

A.7.1 First Iteration to Estimate Bessel Function Cutoff Frequency (f_c)—This section displays the initial calculations which are performed to estimate the correct value of the cutoff frequency (f_c).

The results from Equation A1 indicate that the desired filter response (t_{Fd}) is 0.4995 (for simplicity, a value of 0.50 will be used in the sample calculations). This may be typical of a full flow meter with a very fast electrical and physical response time. It suggests that most of the desired 0.500 s filtering will be performed by the digital filter rather than the instrument.

$$t_{Fd} = 0.4995 = \text{SQRT}[0.500^2 - (0.020^2 + 0.010^2)] \qquad \text{(Eq.A11)}$$

By inserting the correct values of Δt and t_F into Equations A2 through A7, the Bessel function coefficients are determined. These are shown in Table A1.

TABLE A1—INITIAL BESSEL COEFFICIENTS

Equation A1	t_F	0.500
Equation A2	f_c	0.6283
Equation A4	B	0.618
Equation A5	Ω	50.6555063
Equation A6	C	0.00060396
Equation A7	K	0.91427037
	Δt	0.01

The Bessel coefficients can now be in ed into Eq on A8 along with the step input function (i.e., an input of 0% opacity to 100% opacity in 0.01 o illustrate e effect of the Bessel filter on the step response as a function of time. The input step function is shown as X_i in Table A2. To simulate the step response, input X_1 = 100. This will create the sudden jump from 0 to 100%.

The Bessel filtered output is shown as Y_i in Table A2. The two output points which are of interest are the 10% response point and the 90% response point. These are the values where Y_i first exceeds 10% and 90%. Since the output Y_i is digital, the exact 10% and 90% points must be interpolated from Table A2. The four points which bound the 10% and 90% points are indicated by an "X" in the Index column of Table A2. These are index numbers 9, 10, and 64, 65.

For this specific case, the following interpolation formulas are used to calculate the values of $t_{10\%}$ and $t_{90\%}$.

$$t_{10\%} = 0.01 * [9 + (10 - 8.647)/(10.260 - 8.647)] = 0.0984 \text{ s} \quad \text{(Eq.A12)}$$

$$t_{90\%} = 0.01 * [64 + (90 - 89.834)/(90.427 - 89.834)] = 0.6428 \text{ s} \quad \text{(Eq.A13)}$$

Now calculate the difference between $t_{90\%}$ and $t_{10\%}$ and see if it is close enough to t_F (close enough means within 1% or in this case 0.005).

$$0.6428 - 0.0984 = 0.5444 \text{ s} \quad \text{(Eq.A14)}$$

The calculation shows that the response time of the filter is 0.5444 s using a value of f_c of 0.6283. The difference between this value and the desired value of 0.50 is 0.0444 which is about 10% greater than desired. Thus, another attempt to reach the desired response time will have to be made. Since 0.5444 is about 10% too high, use a cutoff frequency (f_c) which is 10% larger for the second iteration.

A.7.2 Second Iteration to Estimate Bessel Function Cutoff Frequency (f_c)—For the second iteration, a value of 0.690 is chosen for the value of f_c. This is approximately 10% higher than the value previously used. When this value is used, the Bessel function coefficients in Table A3 are obtained.

The filter responses Y_i were also recalculated for the step input X_i. The entire table of inputs (X_i) and responses (Y_i) (analogous to Table A2) is not shown. However, the values of t_{10} and t_{90} and the difference between were calculated and are shown in Table A4. In this case, the difference between the filter response time and the desired filter response time of 0.50 s is 0.0049. This is less than the 1% difference criteria (0.005 s). Thus, the value of 0.692 for the frequency cutoff (f_c) is the correct one for this smokemeter application.

A.7.3 Sample Calculation of the Bessel Filter Opacity Response—Once the appropriate value for the cutoff frequency (f_c) has been determined, then Equations A4 through A8 are used to calculate the Bessel filtered opacity values (Y_i) for any given input opacity values (X_i). The maximum filtered response is then selected and reported as the smoke reading for that particular snap-acceleration cycle.

TABLE A2—INITIAL SIMULATION OF THE BESSEL FILTER EFFECT (USED TO DETERMINE f_c)

Index	Time	X_i	X_{i-1}	X_{i-2}	Y_i	Y_{i-1}	Y_{i-2}
0	0.00	100	0	0	0.060	0.000	0.000
1	0.01	100	100	0	0.297	0.060	0.000
2	0.02	100	100	100	0.754	0.297	0.060
3	0.03	100	100	100	1.414	0.754	0.297
4	0.04	100	100	100	2.256	1.414	0.754
5	0.05	100	100	100	3.264	2.256	1.414
6	0.06	100	100	100	4.423	3.264	2.256
7	0.07	100	100	100	5.715	4.423	3.264
8	0.08	100	100	100	7.128	5.715	4.423
X 9	0.09	100	100	100	8.647	7.128	5.715
X 10	0.10	100	100	100	10.260	8.647	7.128
11	0.11	100	100	100	11.956	10.260	8.647
12	0.12	100	100	100	13.723	11.956	10.260
13	0.13	100	100	100	15.552	13.723	11.956
14	0.14	100	100	100	17.432	15.552	13.723
15	0.15	100	100	100	19.355	17.432	15.552
16	0.16	100	100	100	21.312	19.355	17.432
17	0.17	100	100	100	23.297	21.312	19.355
18	0.18	100	100	100	25.301	23.297	21.312
19	0.19	100	100	100	27.319	25.301	23.297
20	0.20	100	100	100	29.344	27.319	25.301
21	0.21	100	100	100	31.372	29.344	27.319
22	0.22	100	100	100	33.396	31.372	29.344
23	0.23	100	100	100	35.413	33.396	31.372
24	0.24	100	100	100	37.417	35.413	33.396
25	0.25	100	100	100	39.406	37.417	35.413
26	0.26	100	100	100	41.375	39.406	37.417
27	0.27	100	100	100	43.322	41.375	39.406
28	0.28	100	100	100	45.244	43.322	41.375
29	0.29	100	100	100	47.138	45.244	43.322
30	0.30	100	100	100	49.001	47.138	45.244
31	0.31	100	100	100	50.833	49.001	47.138
32	0.32	100	100	100	52.631	50.833	49.001
33	0.33	100	100	100	54.394	52.631	50.833
34	0.34	100	100	100	56.119	54.394	52.631
35	0.35	100	100	100	57.807	56.119	54.394
36	0.36	100	100	100	59.457	57.807	56.119
37	0.37	100	100	100	61.067	59.457	57.807
38	0.38	100	100	100	62.637	61.067	59.457
39	0.39	100	100	100	64.166	62.637	61.067
40	0.40	100	100	100	65.654	64.166	62.637
41	0.41	100	100	100	67.102	65.654	64.166
42	0.42	100	100	100	68.508	67.102	65.654
43	0.43	100	100	100	69.873	68.508	67.102
44	0.44	100	100	100	71.198	69.873	68.508

TABLE A2—INITIAL SIMULATION OF THE BESSEL FILTER EFFECT (USED TO DETERMINE f_c) (CONTINUED)

Index	Time	X_i	X_{i-1}	X_{i-2}	Y_i	Y_{i-1}	Y_{i-2}
45	0.45	100	100	100	72.481	71.198	69.873
46	0.46	100	100	100	73.724	72.481	71.198
47	0.47	100	100	100	74.927	73.724	72.481
48	0.48	100	100	100	76.090	74.927	73.724
49	0.49	100	100	100	77.215	76.090	74.927
50	0.50	100	100	100	78.300	77.215	76.090
51	0.51	100	100	100	79.348	78.300	77.215
52	0.52	100	100	100	80.358	79.348	78.300
53	0.53	100	100	100	81.331	80.358	79.348
54	0.54	100	100	100	82.269	81.331	80.358
55	0.55	100	100	100	83.171	82.269	81.331
56	0.56	100	100	100	84.039	83.171	82.269
57	0.57	100	100	100	84.872	84.039	83.171
58	0.58	100	100	100	85.673	84.872	84.039
59	0.59	100	100	100	86.442	85.673	84.872
60	0.60	100	100	100	87.180	86.442	85.673
61	0.61	100	100	100	87.887	87.180	86.442
62	0.62	100	100	100	88.564	87.887	87.180
63	0.63	100	100	100	89.213	88.564	87.887
X 64	0.64	100	100	100	89.834	89.213	88.564
X 65	0.65	100	100	100	90.427	89.834	89.213
66	0.66	100	100	100	90.994	90.427	89.834
67	0.67	100	100	100	91.536	90.994	90.427
68	0.68	100	100	100	92.053	91.536	90.994
69	0.69	100	100	100	92.546	92.053	91.536
70	0.70	100	100	100	93.016	92.546	92.053

TABLE A3—FINAL BESSEL COEFFICIENTS

Equation A1	t_F	0.500
Equation A2	f_c	0.6292
Equation A4	B	0.618000
Equation A5	Ω	45.991292
Equation A6	C	0.000729
Equation A7	K	0.905717
	Δt	0.01

TABLE A4—BOUNDARY RESPONSE TIMES (SECOND ITERATION)

$t_{10\%}$	0.09145
$t_{90\%}$	0.5856
$\Delta\ t_{90\%} - t_{10\%}$	0.4951

Table A5 shows a sample calculation for an actual snap-acceleration smoke event collected at 100 Hz. Only 100 (1 s) readings and calculated values are shown so as to reduce the length of the table. The Bessel coefficients shown in Table A3 are used with Equation A8 to calculate the Bessel filter responses (Y_i) to the raw smoke inputs (X_i).

TABLE A5—BESSEL FILTER EXAMPLE

Time	X_i	X_{i-1}	X_{i-2}	Y_i	Y_{i-1}	Y_{i-2}
0.00	0.00	0.00	0.00	0.000	0.000	0.000
0.01	0.00	0.00	0.00	0.000	0.000	0.000
0.02	0.30	0.00	0.00	0.000	0.000	0.000
0.03	0.60	0.30	0.00	0.001	0.000	0.000
0.04	0.50	0.60	0.30	0.004	0.001	0.000
0.05	0.40	0.50	0.60	0.007	0.004	0.001
0.06	0.30	0.40	0.50	0.012	0.007	0.004
0.07	0.10	0.30	0.40	0.017	0.012	0.007
0.08	0.00	0.10	0.30	0.021	0.017	0.012
0.09	0.00	0.00	0.10	0.026	0.021	0.017
0.10	0.00	0.00	0.00	0.029	0.026	0.021
0.11	0.00	0.00	0.00	0.033	0.029	0.026
0.12	0.00	0.00	0.00	0.036	0.033	0.029
0.13	0.20	0.00	0.00	0.039	0.036	0.033
0.14	0.40	0.20	0.00	0.042	0.039	0.036
0.15	0.40	0.40	0.20	0.045	0.042	0.039
0.16	0.30	0.40	0.40	0.049	0.045	0.042
0.17	0.30	0.30	0.40	0.054	0.049	0.045
0.18	0.70	0.30	0.30	0.059	0.054	0.049
0.19	0.80	0.70	0.30	0.066	0.059	0.054
0.20	0.70	0.80	0.70	0.073	0.066	0.059
0.21	0.40	0.70	0.80	0.082	0.073	0.066
0.22	0.20	0.40	0.70	0.091	0.082	0.073
0.23	0.20	0.20	0.40	0.100	0.091	0.082
0.24	0.30	0.20	0.20	0.108	0.100	0.091
0.25	0.50	0.30	0.20	0.116	0.108	0.100
0.26	0.40	0.50	0.30	0.124	0.116	0.108
0.27	0.20	0.40	0.50	0.133	0.124	0.116
0.28	0.00	0.20	0.40	0.140	0.133	0.124
0.29	0.40	0.00	0.20	0.147	0.140	0.133
0.30	0.30	0.40	0.00	0.154	0.147	0.140
0.31	0.20	0.30	0.40	0.161	0.154	0.147
0.32	0.20	0.20	0.30	0.167	0.161	0.154
0.33	0.10	0.20	0.20	0.172	0.167	0.161
0.34	0.10	0.10	0.20	0.177	0.172	0.167
0.35	0.30	0.10	0.10	0.182	0.177	0.172
0.36	0.70	0.30	0.10	0.186	0.182	0.177
0.37	1.10	0.70	0.30	0.192	0.186	0.182
0.38	2.60	1.10	0.70	0.200	0.192	0.186
0.39	3.50	2.60	1.10	0.215	0.200	0.192

TABLE A5—BESSEL FILTER EXAMPLE (CONTINUED)

Time	X_i	X_{i-1}	X_{i-2}	Y_i	Y_{i-1}	Y_{i-2}
0.40	7.10	3.50	2.60	0.239	0.215	0.200
0.41	10.20	7.10	3.50	0.281	0.239	0.215
0.42	15.90	10.20	7.10	0.350	0.281	0.239
0.43	21.80	15.90	10.20	0.458	0.350	0.281
0.44	28.10	21.80	15.90	0.619	0.458	0.350
0.45	34.40	28.10	21.80	0.846	0.619	0.458
0.46	39.90	34.40	28.10	1.149	0.846	0.619
0.47	44.80	39.90	34.40	1.537	1.149	0.846
0.48	50.30	44.80	39.90	2.016	1.537	1.149
0.49	52.70	50.30	44.80	2.590	2.016	1.537
0.50	56.40	52.70	50.30	3.259	2.590	2.016
0.51	58.80	56.40	52.70	4.020	3.259	2.590
0.52	61.50	58.80	56.40	4.873	4.020	3.259
0.53	63.40	61.50	58.80	5.812	4.873	4.020
0.54	64.70	63.40	61.50	6.832	5.812	4.873
0.55	65.00	64.70	63.40	7.928	6.832	5.812
0.56	66.20	65.00	64.70	9.091	7.928	6.832
0.57	66.40	66.20	65.00	10.313	9.091	7.928
0.58	68.30	66.40	66.20	11.589	10.313	9.091
0.59	67.00	68.30	66.40	12.911	11.589	10.313
0.60	66.30	67.00	68.30	14.271	12.911	11.589
0.61	66.40	66.30	67.00	15.659	14.271	12.911
0.62	65.90	66.40	66.30	17.068	15.659	14.271
0.63	66.10	65.90	66.40	18.491	17.068	15.659
0.64	63.50	66.10	65.90	19.921	18.491	17.068
0.65	63.40	63.50	66.10	21.349	19.921	18.491
0.66	61.20	63.40	63.50	22.768	21.349	19.921
0.67	59.90	61.20	63.40	24.170	22.768	21.349
0.68	59.40	59.90	61.20	25.549	24.170	22.768
0.69	58.20	59.40	59.90	26.900	25.549	24.170
0.70	56.60	58.20	59.40	28.218	26.900	25.549
0.71	54.70	56.60	58.20	29.499	28.218	26.900
0.72	53.80	54.70	56.60	30.737	29.499	28.218
0.73	53.40	53.80	54.70	31.930	30.737	29.499
0.74	51.70	53.40	53.80	33.075	31.930	30.737
0.75	50.80	51.70	53.40	34.171	33.075	31.930
0.76	48.80	50.80	51.70	35.214	34.171	33.075
0.77	48.30	48.80	50.80	36.203	35.214	34.171
0.78	45.80	48.30	48.80	37.135	36.203	35.214
0.79	45.30	45.80	48.30	38.009	37.135	36.203
0.80	44.30	45.30	45.80	38.823	38.009	37.135
0.81	42.00	44.30	45.30	39.579	38.823	38.009
0.82	42.20	42.00	44.30	40.274	39.579	38.823
0.83	39.90	42.20	42.00	40.910	40.274	39.579
0.84	39.20	39.90	42.20	41.485	40.910	40.274
0.85	39.10	39.20	39.90	42.002	41.485	40.910
0.86	36.90	39.10	39.20	42.462	42.002	41.485

TABLE A5—BESSEL FILTER EXAMPLE (CONTINUED)

Time	X_i	X_{i-1}	X_{i-2}	Y_i	Y_{i-1}	Y_{i-2}
0.87	36.50	36.90	39.10	42.865	42.462	42.002
0.88	35.20	36.50	36.90	43.211	42.865	42.462
0.89	34.50	35.20	36.50	43.503	43.211	42.865
0.90	34.90	34.50	35.20	43.743	43.503	43.211
0.91	32.70	34.90	34.50	43.934	43.743	43.503
0.92	32.10	32.70	34.90	44.075	43.934	43.743
0.93	31.50	32.10	32.70	44.169	44.075	43.934
0.94	30.50	31.50	32.10	44.216	44.169	44.075
0.95	30.70	30.50	31.50	44.220	44.216	44.169
0.96	30.20	30.70	30.50	44.184	44.220	44.216
0.97	29.30	30.20	30.70	44.110	44.184	44.220
0.98	26.90	29.30	30.20	43.999	44.110	44.184
0.99	25.80	26.90	29.30	43.848	43.999	44.110
1.00	25.30	25.80	26.90	43.660	43.848	43.999

APPENDIX B
CORRECTIONS FOR AMBIENT TEST CONDITIONS

B.1 Introduction—Adjustment of snap-acceleration smoke values for the influence of ambient measurement conditions is an important and integral part of the SAE J1667 smoke measurement procedure. Testing has shown at-site ambient environmental conditions to be among the most influential testing factors that affect as-measured snap-acceleration smoke results. The ambient environmental factors incurred at the point of measurement in the form of altitude, barometric pressure, air temperature, and humidity have been combined into the single parameter of dry air density in order to provide a means of accounting for the influence of these factors on snap-acceleration test results. This appendix details procedures and offers guidelines for performing this important adjustment to snap-acceleration smoke values.

As will be summarized in Section B.7, the adjustment equations provided in this appendix were derived from an extensive snap-acceleration smoke test program involving a wide variety of heavy-duty diesel powered vehicles. One of the main conclusions of this test program was that each of the engines powering the test vehicles displayed different degrees of sensitivity to changes in air density. These differences were likely due to the different combustion and smoke control technologies employed by these engines at the time of their manufacture.

The air density adjustment equations provided in this appendix reflect the best fit nominal sensitivity of the sample of engines/vehicles evaluated. Some engines were more sensitive, and some were less sensitive, to the air density changes than predicted by the adjustment equations. In light of this, applying the correction equations to specific engines/vehicles of unknown air density sensitivity, the adjustment equations can only be considered approximate. It is recommended that regulatory agencies adopting this procedure in enforcement programs make some allowance for the fact that the air density sensitivity of individual vehicles tested in the program will, in general, not be known precisely and may be different than indicated by the nominal adjustment.

B.1.1 Reference Conditions—To perform an air density adjustment to an observed smoke value, it is necessary to define a reference air density which is used as the basis for the adjustment. The reference dry air density which was selected is:

$$1.1567 \text{ kg/m}^3 \ (0.0722 \text{ lbm/ft}^3)$$

This dry air density is the reference density specified in SAE J1349 and J1995, which specify the net and gross power rating conditions for diesel engines.

B.1.2 Precautions

a. The air density extremes encountered during the smoke test program (see Section B.7) used to derive the adjustment equations ranged from a low of 0.908 kg/m^3 (0.0567 lbm/ft^3) to a high of 1.235 kg/m^3 (0.0771 lbm/ft^3). The adjustment equations provided in this appendix should not be used outside of this range of air density.

b. The results from the study used to develop these correction factors suggested that at high temperatures above 32 °C (90 °F) and at low altitude sites around 412 m (1350 ft) in elevation there appeared to be a systematic temperature effect present that may not be accounted for by these correction factors. Residuals (the difference between measured values and calculated values) at these sites tend to decrease in value with increasing temperature. This may suggest the need for further adjustments to the equations to account for these temperature trends.

c. The air density adjustment equations presented here were developed specifically for use with snap-acceleration smoke values obtained using the procedures, equipment, and analysis techniques described in this document. The adjustment equations are not recommended for use with snap-acceleration smoke values obtained using peak-reading type smokemeters, or other smoke measurement procedures.

B.2 Symbols

A = Final avg. snap-acceleration test result, in units of opacity (%) or smoke density K(m^{-1}), from Equation A4. "A" is equivalent to N_t or K_t, depending on the smoke units being used.
BARO = Barometric pressure, absolute, kPa (in-Hg).
c = Regression coefficient for ambient condition adjustment equation.
DBT = Dry bulb temperature, ambient temperature measured in conjunction with WBT, °C (°F).
DPT = Dew point temperature, °C (°F).
F = Ferrel's equation, saturation pressure adjustment factor.
K = Smoke density (extinction coefficient), per meter (m^{-1}).
N = Smoke opacity, in percent (%).
ρ = Air density (dry), kg/m^3 (lbm/ft^3).
$\Delta\rho$ = Dry air density differential between actual test conditions or reference conditions, and base conditions.
RH = Relative humidity, percent (%).
SPT = Water saturation pressure at the ambient temperature, kPa (in-Hg).
SPWBT = Water saturation pressure at the wet bulb temperature, kPa (in-Hg).
T = Ambient temperature, if different from the DBT, °C (°F).
WBT = Wet bulb temperature, °C (°F).
WVP = Water vapor pressure, kPa (in-Hg).

NOTE—Pressure units given in in-Hg are referenced to 0 °C.

subscripts

abs = absolute temperature. T + 273.15 Kelvin (T + 459.67 °R)
base = base dry air density. The air density upon which the ambient conditions correction regression coefficients are based.
ref = at reference dry air density conditions, 1.1567 kg/m^3 (0.0722 lbm/ft^3).
t = at non-reference dry air density, usually actual test dry air density.

B.3 Snap-Acceleration Smoke Adjustment Methods—This appendix contains snap-acceleration adjustment equations that account for the air density effects on snap-acceleration smoke. The measured vehicle smoke value (A) is adjusted to the reference air density (ρ_{ref}). The measured smoke value (A), along with the actual dry air density (ρ_t) at the time of the test, are used in Section B.4 for opacity units or Section B.5 for smoke density units to compute the smoke level (N_{ref} or K_{ref}) at the reference air density (ρ_{ref}).

B.4 Adjustment of Snap-Acceleration Smoke Opacity (N) Values for the Effects of Changes in the Dry Air Density—The approach for adjusting smoke opacity values for the effects of changes in the dry air density is to convert the smoke opacity value, N_t, to smoke density units (K), adjust the smoke density value according to the procedures described in Section B.5, and then re-convert the adjusted smoke density value back into smoke opacity units as N_{ref}.

To adjust a snap-acceleration smoke opacity value for the effects of changes in the dry air density:

1. Convert the smoke opacity value to the equivalent smoke density units using the following equation:

$$K = (-1/L) \cdot 1n(1 - (N/100)) \qquad \text{(Eq.B1)}$$

where:

K = Smoke density (m^{-1}).
L = Optical path length of the smoke measurement, in meters (m). If L is not known, assume a value of 0.127 m.
N = Smoke opacity value to be converted, usually N_t.

2. Adjust the resulting smoke density value, calculated in step 1, according to the procedures described in Section B.5 to produce K_{ref}.

3. Convert the resulting adjusted smoke density value calculated in Section B.5 to equivalent smoke opacity units according to the following equation:

$$N = (1 - e^{-KL}) \cdot 100 \qquad \text{(Eq.B2)}$$

where:

N = Ambient conditions adjusted smoke opacity value, N_{ref}.
K = Ambient conditions adjusted smoke density value, K_{ref}, determined in Section B.5.
L = Optical path length value used in Equation B1.

NOTE—It is important to use the same value of L (optical path length) for the conversion to smoke density units and for the re-conversion back to smoke opacity units. The actual value of L is not critical; however, it must be a positive non-zero value.

B.5 Adjustment of Snap-Acceleration Smoke Density (K) Values for the Effects of Changes in the Dry Air Density—The base air density (ρ_{base}) parameter used in this section should not be confused with the reference air density (ρ_{ref}). The base air density is the ambient condition used to develop the adjustment regression coefficient used in this section. The adjustment equations in this section provide for the reference air density to be different from the base air density used in the regression analysis of the ambient conditions test data.

To adjust a measured snap-acceleration smoke density value to reference air density conditions:

1. Calculate the air density differences using ρ_{ref} and ρ_{base}:

$$\Delta\rho_1 = \rho_{ref} - \rho_{base} \qquad \text{(Eq.B3)}$$

$$\Delta\rho_2 = \rho_t - \rho_{base} \qquad \text{(Eq.B4)}$$

2. Calculate the adjusted snap-acceleration smoke density value, K_{ref}, at the reference dry air density, using Equation B5, and the appropriate values for coefficient c and r from Table B1.

$$K_{ref} = K_t \cdot \frac{\left(c \cdot \Delta\rho_1^{\,2} + 1\right)}{\left(c \cdot \Delta\rho_2^{\,2} + 1\right)} \qquad \text{(Eq.B5)}$$

TABLE B1—SMOKE DENSITY ADJUSTMENT CONSTANTS

Air Density Units	c	ρ_{base}	
kg/m³	21.1234	1.2094	(metric)
lbm/ft³	5420.0671	0.0755	(English)

3. Substituting the values in Table B1 for c and ρ into Equation B3 through B5 produces Equation B6 and B7 for K_{ref}.

Metric Units ρ (kg/m³)

$$K_{ref} = \frac{K_t}{19.952\,\rho_t^{\,2} - 48.259\,\rho_t + 30.126} \qquad \text{(Eq.B6)}$$

English Units ρ (lbm/ft³)

$$K_{ref} = \frac{K_t}{5119.55\,\rho_t^{\,2} - 773.05\,\rho_t + 30.126} \qquad \text{(Eq.B7)}$$

B.6 Calculation of Dry Air Density—In order to correct the smoke values using the equations in Sections B.4 or B.5, it is first necessary to determine the dry air density at the test conditions. This can be done by measuring the barometric pressure (BARO), the ambient air temperature (T or DBT), and either the dew point temperature (DPT), or the wet and dry bulb temperatures (WBT and DBT), or the relative humidity (RH). From these measurements the dry air density may be determined from the following equation.

$$\rho = (u * (BARO - WVP))/(T_{abs}) \qquad \text{(Eq.B8)}$$

where:

TABLE B2

	Metric	English
ρ, Air Density (dry)	kg/m^3	lbm/ft^3
Units conversion (u)	3.4836	1.3255
Barometric Pressure (BARO)	kPa	in-Hg
Water Vapor Pressure (WVP)	kPa	in-Hg
Ambient Temperature (T_{abs})	Kelvin	°R

The barometric pressure and the ambient temperature must be measured at the test conditions of interest. The water vapor pressure may be calculated as described in B.6.1, or obtained from a psychrometric chart.

NOTE—Exclusion of the water vapor pressure term in Equation B8 (calculation of dry air density) is permissible, thus eliminating the need to measure DPT, WBT, or RH and calculate the WVP. However, the user should be aware that this results in a bias error, usually towards a smaller adjustment factor applied to the smoke values. In addition, it should be noted that as the ambient temperature increases, the amount of water the air can hold increases rapidly, and thus, the potential impact of this error also increases. The examples in Section B.6 illustrate the impact of ignoring the water vapor pressure in the adjustment equations.

B.6.1 Calculation of Water Vapor Pressure (WVP)—The method of calculating the water vapor pressure is dependent upon the instrumentation used to determine the moisture in the ambient air. The most common methods utilized are by the measurement of the dew point temperature (DPT), the measurement of the wet bulb/dry bulb temperatures, and by the measurement of the relative humidity (RH). From these measurements, the vapor pressure of the air may be determined.

B.6.1.1 CALCULATION OF WVP FROM DEW POINT TEMPERATURE—This procedure uses a dimensionless (normalized) polynomial for the vapor pressure calculation. This allows calculations to be performed in any units, utilizing the same polynomial coefficients. In using this technique, the input and output parameters to the polynomial are normalized and un-normalized, respectively, with the supplied support equations.

a. Calculate the normalized dew point temperature (NT) from the measured dew point temperature (DPT).

$$NT = (DPT - TL)/(TH - TL) \qquad \text{(Eq.B9)}$$

TABLE B3

Temperature Units	TL	TH
°C	−30.0	+40.0
°F	−22.0	+104.0

NOTE—DPT, TL, and TH must be in the same temperature units. Equation B9 applies over a dew point temperature range of −30 to +40 °C (−22 to +104 °F).

b. Calculate the normalized water vapor pressure (NP) at the normalized dew point temperature (NT).

$$\begin{aligned} NP = & -4.959658E\text{-}5 + (4.956773E\text{-}2 \cdot NT) \\ & + (9.455172E\text{-}2 \cdot NT^2) + (4.199096E\text{-}1 \cdot NT^3) \\ & + (-7.549164E\text{-}2 \cdot NT^4) + (5.114628E\text{-}1 \cdot NT^5) \end{aligned} \tag{Eq.B10}$$

c. Un-normalize the saturation pressure (NP) to produce the WVP at the dew point temperature, DPT, in the units of choice.

$$WVP = PL + (NP \cdot (PH - PL)) \tag{Eq.B11}$$

TABLE B4

Pressure Units	PL	PH
kPa	5.0951E-2	7.375
in-Hg	1.5046E-2	2.178

NOTE—WVP, PL, and PH must be in the same pressure units.

B.6.1.2 CALCULATION OF WVP FROM WET BULB/DRY BULB TEMPERATURES—This procedure uses a dimensionless (normalized) polynomial for the vapor pressure calculation. This allows calculations to be performed in any units, utilizing the same polynomial coefficients. In using this technique, the input and output parameters to the polynomial are normalized and un-normalized, respectively, with the supplied support equations.

a. Calculate the normalized wet bulb temperature (NT) from the measured wet bulb temperature (WBT).

$$NT = (WBT - TL)/(TH - TL) \tag{Eq.B12}$$

TABLE B5

Temperature Units	TL	TH
°C	−30.0	+40.0
°F	−22.0	+104.0

NOTE—WBT, TL, and TH must be in the same temperature units. Equation B12 applies over a wet bulb temperature range of −30 to +40 °C (−22 to +104 °F).

b. Calculate the normalized saturation pressure (NP) at the normalized wet bulb temperature (NT).

$$NP = -4.959658E\text{-}5 + (4.956773E\text{-}2 * NT) + (9.455172E\text{-}2 * NT^2) + (4.199096E\text{-}1 * NT^3) + (-7.549164E\text{-}2 * NT^4) + (5.114628E\text{-}1 * NT^5) \quad \text{(Eq.B13)}$$

c. Un-normalize the saturation pressure (NP) to produce the saturation pressure at the wet bulb temperature, SPWBT, in the units of choice.

$$SPWBT = PL + (NP * (PH - PL)) \quad \text{(Eq.B14)}$$

TABLE B6

Pressure Units	PL	PH
kPa	5.0951E-2	7.375
in-Hg	1.5046E-2	2.178

NOTE—SPWBT, PL, and PH must be in the same pressure units.

d. Using Ferrel's equation, calculate the adjustment factor (F).

Metric Units—WBT in °C

$$F = 3.67E\text{-}4 * (1 + (1.152E\text{-}3 * WBT)) \quad \text{(Eq.B15)}$$

English Units—WBT in °F

$$F = 3.67E\text{-}4 * (1 + (6.4E\text{-}4 * (WBT - 32))) \quad \text{(Eq.B16)}$$

e. Calculate the Water Vapor Pressure (WVP).

Metric Units—SPWBT, BARO in kPa; DBT, WBT in °C.

$$WVP = SPWBT - (1.8 * F * BARO * (DBT - WBT)) \quad \text{(Eq.B17)}$$

English Units—SPWB, BARO in in-Hg; DBT, WBT in °F.

$$WVP = SPWBT - (F * BARO * (DBT - WBT)) \quad \text{(Eq.B18)}$$

B.6.1.3 CALCULATION OF WVP FROM RELATIVE HUMIDITY AND AMBIENT TEMPERATURE—This procedure uses a dimensionless (normalized) polynomial for the vapor pressure calculation. This allows calculations to be performed in any units, utilizing the same polynomial coefficients. In using this technique, the input and output parameters to the polynomial are normalized and un-normalized, respectively, with the supplied support equations.

a. Calculate the normalized ambient temperature (NT) from the measured ambient temperature (T).

$$NT = (T - TL)/(TH - TL) \tag{Eq.B19}$$

TABLE B7

Temperature Units	TL	TH
°C	−30.0	+40.0
°F	−22.0	+104.0

NOTE—T, TL, and TH must be in the same temperature units. Equation B19 applies over an ambient temperature range of −30 to +40 °C (−22 to +104 °F).

b. Calculate the normalized saturation pressure (NP) at the normalized ambient temperature (NT).

$$\begin{aligned} NP = & -4.959658E\text{-}5 + (4.956773E\text{-}2 * NT) \\ & + (9.455172E\text{-}2 * NT^2) + (4.199096E\text{-}1 * NT^3) \\ & + (-7.54916E\text{-}2 * NT^4) + (5.114628E\text{-}1 * NT^5) \end{aligned} \tag{Eq.B20}$$

c. Un-normalize the saturation pressure (NP) to produce the saturation pressure at the ambient temperature, SPT, in the units of choice.

$$SPT = PL + (NP * (PH - PL)) \tag{Eq.B21}$$

TABLE B8

Pressure Units	PL	PH
kPa	5.0951E-2	7.375
in-Hg	1.5046E-2	2.178

NOTE—SPT, PL, and PH must be in the same pressure units.

d. Calculate the WVP at the measured relative humidity, RH. WVP will be in the same units as SPT.

$$WVP = SPT * (RH/100) \tag{Eq.B22}$$

B.7 Examples of Adjustments to Ambient Smoke Values—The following hypothetical examples may assist in applying the ambient correction equations. Both metric and English unit based examples are provided. Also included for reference are the applicable equation numbers used in this appendix.

Example 1

Situation—A vehicle tested for smoke at a moderate elevation produces an average snap-acceleration smoke value of 60% opacity (the (A) value reported from Equation B3).

Task—From the ambient conditions measurements, determine the adjusted smoke opacity (N_{ref}) at the reference air density (ρ_{ref}).

Ambient measurements	Equation Constants
Smoke (A) = 60% opacity	c = 54.200671
(BARO) = 27.00 in-Hg	TL = −22 °F
(T) = 77 °F	TH = 104 °F
(RH) = 50%	PL = 1.5046E-2 in-Hg
	PH = 2.178 in-Hg
	EOPL = 0.127 m
	(ρ_{ref}) = 0.0722 lbm/ft³
	(ρ_{base}) = 0.0755 lbm/ft³

Calculations:

(Eq.B19) $NT = (77 - (-22))/(104 - (-22)) = 0.785714$

(Eq.B20) $NP = 0.425334$ (polynomial)

(Eq.B21) $SPT = 1.5046E\text{-}2 + 0.425334 * (2.178 - 1.5046E\text{-}2) = 0.935024$

(Eq.B22) $WVP = 0.935024 * (50.0/100) = 0.4675$

(Eq.B8) $\rho_{dry} = (1.3255 * (27.0 - 0.4675))/(77 + 459.67) = 0.06553$

(Eq.B1) $K_t = 7.215$

(Eq.B3) $\Delta\rho_1 = 0.0722 - 0.0755 = -0.0033$

(Eq.B4) $\Delta\rho_2 = 0.06553 - 0.0755 = -0.00996$

(Eq.B5) $K_{ref} = 4.966$

(Eq.B2) $N_{ref} = 46.8\%$

Result—A vehicle with a snap-acceleration smoke level of 60% opacity at a dry air density of 0.0655 lbm/ft³ would be projected to produce a smoke value of 46.8% opacity at the reference dry air density of 0.0722 lbm/ft³.

It should be noted that if the RH measurement had not been performed and the effect of WVP ignored, the resulting impact would have changed N_{ref} from 46.8% to 49.5% opacity.

Example 2

Situation—A vehicle tested for smoke at a moderate elevation produces an average snap-acceleration smoke density of 7.2 m^{-1} (the (A) value reported from Equation B3).

Task—From the ambient conditions measurements, determine the adjusted smoke density (K_{ref}) at the reference air density (ρ_{ref}).

Ambient measurements	Equation Constants
Smoke (A) = 7.2 m^{-1}	c = 0.211234
(BARO) = 88.50 kPa	TL = −30 °C
(T) = 20 °C	TH = 40 °C
(DPT) = 10 °C	PL = 5.0951E-2 kPa
	PH = 7.375 kPa
	(ρ_{ref}) = 1.1567 kg/m^3
	(ρ_{base}) = 1.2094 kg/m^3

Calculations:

(Eq.B9) NT = (10 − (−30))/(40 − (−30)) = 0.571428

(Eq.B10) NP = 0.160612 (polynomial)

(Eq.B11) WVP = 5.0951E-2 − (0.160612 * (7.375 − 5.0951E-2))
= 1.2272

(Eq.B8) ρ_{dry} = (3.4836 * (88.5 − 1.227))/(20 + 273.15)
= 1.0370

(Eq.B3) $\Delta\rho_1$ = 1.1567 − 1.2094 = −0.0527

(Eq.B4) $\Delta\rho_2$ = 1.0370 − 1.2094 = −0.17230

(Eq.B5) K_{ref} = 4.684 m^{-1}

Result—A vehicle with a snap-acceleration smoke density of 7.2 m^{-1} at a dry air density of 1.0370 kg/m^3 would be projected to produce a smoke density of 4.684 (m^{-1}) at the reference dry air density of 1.1567 kg/m^3.

B.8 Snap-Acceleration/Air Density Field Test Program—The snap-acceleration smoke adjustment equations of this appendix were derived using data from a smoke test program designed to study the effects of ambient conditions on snap-acceleration smoke levels. The test program was conducted during the summer of 1993 and involved measuring the snap-acceleration levels of several heavy-duty diesel-powered vehicles, as the vehicles traveled an out and back route over a wide range of elevations on Interstate 80, in California. The vehicles were tested for snap-acceleration smoke with several types of smokemeters using the SAE J1667 test procedures and data analysis algorithm. Eight tests were performed at six different elevations along the route. At two of the elevations, tests were performed on both the outbound and return legs of the test route. The range of the ambient test conditions encountered during the test program are shown in Table B9.

TABLE B9—TEST PROGRAM AMBIENT EXTREMES

Units	min	max
Metric		
Elevation	12 m	2207 m
Air Density (dry)	0.906 kg/m³	1.235 kg/m³
Air Density (wet)	0.915 kg/m³	1.240 kg/m³
Barometer	78.3 kPa	101.7 kPa
Ambient Temp.	11.7 °C	37.2 °C
Specific Humidity	0.6 gm/kg	12.7 gm/kg
English		
Elevation	40 ft	7240 ft
Air Density (dry)	0.0567 lbm/ft³	0.0771 lbm/ft³
Air Density (wet)	0.0571 lbm/ft³	0.0774 lbm/ft³
Barometer	23.11 in-Hg	30.03 in-Hg
Ambient Temp.	53 °F	99 °F
Specific Humidity	4 grains	89 grains

A total of 24 diesel-powered vehicles were tested in the program, with the number, type, and manufacturer of the diesel engines powering these vehicles providing a fairly representative sample of the engines in the general U.S. heavy-duty vehicle population. Engines manufactured by Caterpillar, Cummins, Detroit Diesel (both 2 and 4 cycle), and Mack were included in the test sample, as were engines with both mechanical and electronic injection control systems. There was one naturally aspirated engine in the test sample with the rest being turbocharged. The manufacturing dates of the engines covered a range from 1971 to 1993 with about 46% of the engines manufactured in the 1985-1989 period and about 33% manufactured between 1990 and 1993.

Four different manufacturers of smokemeters (Bosch, Caltest, Sun, and Wager) participated in the test program. The smokemeters included full flow end-of-line (EOL) and sampling type smokemeters. Both peak-reading meters and prototype meters which were programmed to perform the SAE J1667 half-second averaging algorithm were included in the testing.

The data from the testing program were assembled into a single data base so that standard mathematical and statistical procedures could be utilized to query for relationships among the various test parameters. Data from the peak-reading meters and data which did not meet the SAE J1667 test validation criteria, as given in 5.4.4, were excluded from the analyses. Dry air density, barometric pressure, and altitude all produced significant correlations with the snap-acceleration smoke values, with dry air density providing the better correlation.

The data from this test program were also used to quantify the repeatability of the test procedure. This was done in two ways. In the first method, the average of the ambient condition corrected smoke values was computed for each vehicle, test day and smokemeter combination. The deviations of the individual corrected smoke values from this average were then computed and used to provide a measure of the repeatability of the test procedure over the full range of ambient conditions encountered in the test program and allowed by the procedure. When this was done for all the data in the test program data base, 91% of the deviations from average were less than 6% opacity.

In the second method, only the data taken at the two elevations where repeat tests were run were utilized. For each vehicle/meter combination the two test results obtained at these test locations created a data pair which differed only slightly in ambient dry air density. (Since the elevation was the same for both points in the data pair, the only source of air density differences was the change in ambient conditions which occurred in the few hours between the two tests.) All these smoke values were corrected to the standard reference air density using the methods described in this appendix and the deviation of the corrected smoke values was noted for each data pair. For 90% of the pairs, the deviations were less than 3% opacity.

The difference in the repeatabilities quantified by the two methods reflects the imprecision of applying the ambient condition corrections to specific vehicles over wide ranges of air density.

APPENDIX C
APPLICATION OF CORRECTIONS TO MEASURED SMOKE VALUES

C.1 *Introduction*—Fundamentally, all smoke opacimeters measure the transmittance of light through a smoke plume or a sample of gas which contains smoke particles. Typically, however, it is desired to quantify and report the exhaust smoke emissions in units of either smoke opacity (N) or smoke density (k). Furthermore, if the smoke level is reported as smoke opacity, then is it also necessary to report the associated effective optical path length to fully specify the smoke level of the vehicle. This is because measured smoke opacity is a function of the effective optical path length (EOPL) used to make the measurement. For example, an engine that yielded a 20% opacity when tested with a tailpipe which caused the EOPL to be 76 mm would have measured opacities of 26%, 31%, and 36%, respectively, when tested with larger tailpipes which caused the EOPL to be 102, 127, and 152 mm. Therefore, to facilitate comparisons of smoke opacity data from different sources and with smoke standards which may be developed, opacity values must be reported at standard effective optical path lengths.

When smoke is measured using an effective optical path length which is different than the standard path length, the measured smoke values must be converted to opacity at the standard path length using the appropriate Beer-Lambert relationship. Similarly, if it is desired to report the test results in units of smoke density, it is necessary to use the Beer-Lambert relationship to convert the measured opacity results to smoke density.

Finally, if smoke measurements are made using a smokemeter having a red LED light source, a wavelength correction is necessary to account for the fact that the ability of diesel smoke to absorb light depends on the wavelength of the light.

This appendix describes how measured smoke values are to be corrected to the desired reporting units using the Beer-Lambert relationships and how the light source wavelength corrections are to be made.

C.2 *Definitions and Symbols*

C.2.1 **Diesel Smoke**—Particles, including aerosols, suspended in the exhaust stream of a diesel engine which absorb, reflect, or refract light.

C.2.2 **Transmittance (T)**—The fraction of light transmitted from a source which reaches a light detector.

C.2.3 **Opacity (N)**—The percentage of light transmitted from a source which is prevented from reaching a light detector.

C.2.4 **Effective Optical Path Length (L)**—The length of the smoke obscured optical path between the smokemeter light source and light detector. Note that portions of the total light source to detector path length which are not smoke obscured do not contribute to the effective optical path length.

C.2.5 **Smoke Density (k)**—A fundamental means of quantifying the ability of a smoke plume or a smoke-containing gas sample to prevent the passage of light. By convention, smoke density is expressed on a per meter basis (m^{-1}).

C.2.6 **W**—The wavelength of the smokemeter light source.

C.2.7 Subscripts

C.2.7.1 m—Refers to the as-measured condition

C.2.7.2 s—Refers to values corrected to a standard condition

C.3 Beer-Lambert Relationships—The Beer-Lambert Law defines the relationship between transmittance, smoke density, and effective optical path length as shown in Equation C1.

$$T = e^{-kL} \tag{Eq.C1}$$

From the definitions of transmittance and opacity, the relationship between these parameters may be defined as shown in Equation C2.

$$N\ (\%) = 100 * (1 - T) \tag{Eq.C2}$$

From Equations C1 and C2 the following important relationships can be derived:

$$N_s = 100 * (1 - ((1 - (N_m/100))(L_s/L_m))) \tag{Eq.C3}$$

$$k = -(1/L_m) * (1n\ (1 - (N_m/100))) \tag{Eq.C4}$$

To achieve proper results in applying Equations C1 and C4, the effective optical path lengths (L and L_m) must be expressed in units of meters (m). It is recommended that the effective optical path lengths used in Equation C3 also be expressed in meters (m); however, any length unit may be used as long as L_s and L_m are expressed in the same measurement unit.

C.4 Use of Beer-Lambert Relationships—Conversion from as-measured smoke values to appropriate reporting units is a two-step process. Since, as noted in Section C.1, the basic measurement unit of all smokemeters is transmittance, the first step in all cases is to convert from transmittance (T) to opacity at the as-measured effective optical path length (N_m) using Equation C2. Since all opacimeters do this internally, this step is transparent to the user.

The second step of the process is to convert from N_m to the desired reporting units as follows:

a. If the test results are to be reported in opacity units, Equation C3 must be used to convert from opacity at the as-measured effective optical path length to opacity at the standard effective optical path length. (In the event that the measured and standard effective optical path lengths are identical, N_s is equal to N_m and this secondary conversion step is not required.)

b. If the test results are to be reported in units of smoke density, then Equation C4 must be applied.

C.5 Effective Optical Path Length Input Values—In order to apply conversion Equation C4, it is necessary to input the as-measured effective optical path length (L_m). To use Equation C3, values must be input both for L_m and for L_s, the standard effective optical path length. This section provides guidance on the determination of these input values.

C.5.1 Determination of L_m—For full-flow end-of-line type smokemeters, L_m is a function of the vehicle tailpipe design. For straight tailpipes with a circular cross section, L_m is equal to the tailpipe ID. For tailpipes constructed of common tubing, the tubing OD may be used to approximate the tubing ID. Appendix D provides guidance in determining L_m for other tailpipe configurations.

For sampling type smokemeters, L_m is a fixed function of the meter measurement cell and purge air system design. Specification data supplied by the meter manufacturer should be consulted to determine the appropriate value for L_m when this type of smokemeter is used.

Typically, it is necessary to determine L_m within ±5 mm to achieve corrected smoke results that are accurate within ±2% opacity or ±0.2 m^{-1} smoke density.

C.5.2 Determination of L_s—To ensure meaningful smoke data comparisons, smoke opacity results should be reported at the standard effective optical path lengths, L_s, shown in Table C1. Table C1 is constructed such that the standard effective optical path length increases with the engine power rating and approximates exhaust tailpipe sizes commonly used in vehicle applications. In cases where the engine rated power cannot be determined, the actual tailpipe OD usually provides a good approximation of L_s and may be used in lieu of Table C1.

TABLE C1—STANDARD EFFECTIVE OPTICAL PATH LENGTHS

Rated Engine Power kW	Rated Engine Power BHP	Standard Effective Optical Path Length mm	Standard Effective Optical Path Length in
Less than 75	Less than 101	51	2
75 to 149	101 to 200	76	3
150 to 224	201 to 300	102	4
225 or More	301 or more	127	5

When testing vehicles with multiple exhaust outlets, the total rated engine power must be used with Table C1 to determine the standard effective optical path length. The rated engine power must not be divided by the number of exhaust outlets when using Table C1. If this error is made, it will result in reported smoke opacity values which are erroneously low.

C.6 Sequencing of Beer-Lambert Corrections

C.6.1 Preferred Method—To achieve the highest degree of accuracy, the Beer-Lambert conversion calculations described in Section C.4 should be performed on each instantaneous measured smoke value before any further data-processing takes place. To perform the calculations in this manner during snap-acceleration testing requires significant data-processing capacity since the minimum smoke data-processing rate is 20 Hz. In addition, the ability to input values for L_m and L_s to the data-processing unit is required.

C.6.2 Alternate Methods—In some cases, users may wish to use data-processing systems which are not capable of performing the Beer-Lambert corrections using the preferred method in C.6.1. In these cases, either of the following alternate techniques may be employed; however, users are cautioned that there will be some loss of accuracy.

a. The appropriate Beer-Lambert conversion equations as defined in Section C.4 may be applied after instantaneous smoke values have been averaged using the procedures described in Appendix A. The snap-acceleration test error that results from the use of this method will, in most cases, be less than 1% opacity or 0.15 m^{-1} smoke density, but could be somewhat higher when the snap-acceleration test generates a very high and sharp smoke spike.

b. Appropriate Beer-Lambert conversions may be performed manually on as-measured average smoke values by using the alignment chart shown in Figure C1. In this method, an as-measured smoke opacity (N_m) is located on the vertical column which most closely represents the as-measured effective optical path length (L_m). The user then reads horizontally across the chart to the column which represents the standard effective optical path length (L_s) if a smoke opacity output is desired, or to the smoke density column if a density output is desired. The user then reads the desired output by interpolating the scale of the target column. For example, if an opacity value of 40% were measured using an effective optical path length of 102 mm (4 in), the chart could be used to determine that the equivalent opacity at a path length of 127 mm (5 in) is approximately 47% and that the associated smoke density is about 5.0 m^{-1}.

Since the alignment chart was developed using Equations C3 and C4, the fundamental accuracy of this method is the same as alternate method (a). However, when the as-measured effective optical path length is not equal to one of the values which appear as one of the vertical chart scales the utility and/or accuracy of this method is reduced. This method also introduces the potential for small errors due to resolution and readability of the non-linear chart scales.

C.7 Smokemeter Light Source Wavelength Corrections—The ability of diesel smoke to absorb light is wavelength dependent (i.e., diesel smoke does not have neutral spectral density). For this reason, smokemeters using different light sources will respond differently to the same smoke sample, and corrections are required to achieve comparable results.

Since most smokemeters today use either a green LED or an incandescent light source, with an equivalent peak spectral emissivity, this will be the standard for reporting snap-acceleration test results. Smoke measurements made with meters using red LED light sources must be corrected using the following equations.

$$N_s = 100 * (1 - ((1 - (N_m/100))(w_m/w_s))) \quad \text{(Eq.C5)}$$

$$K_s = (-1/L) * 1n((1 - (N_m/100))(w_m/w_s)) \quad \text{(Eq.C6)}$$

where:

W_s = the wavelength of a standard green LED light source = 570 nm
W_m = the wavelength of a red LED light source = 660 nm

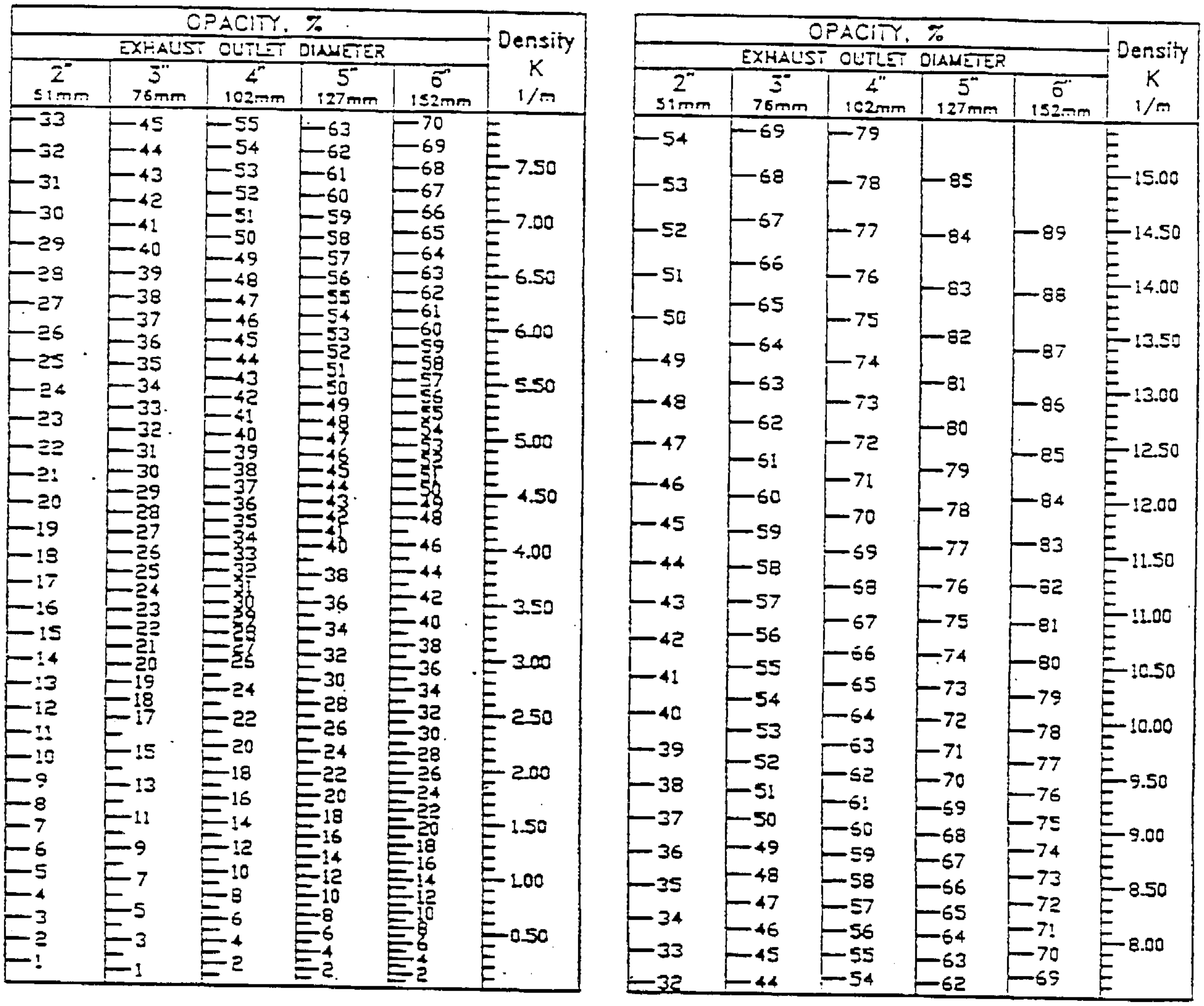


FIGURE C1—ALIGNMENT CHART

It is preferred that the wavelength corrections, like the Beer-Lambert corrections, be applied to each instantaneous measured smoke value. However, if this is not possible, and if small errors are acceptable, the wavelength corrections may be applied after average smoke values are obtained as described in Appendix A.

Light source wavelength corrections using Equations C5 and C6 should be applied when the meter is used to measure diesel smoke, but should not be used when the meter is being calibrated using a neutral density filter.

APPENDIX D
EXHAUST SYSTEMS AND SPECIAL APPLICATIONS

D.1 Introduction—In order to report snap-acceleration test results at standard conditions, the Beer-Lambert effective optical path length corrections described in Appendix C must be applied to the as-measured smoke values. A required input for the Beer-Lambert corrections is the as-measured effective optical path length (L_m). When a sampling type smokemeter is used, L_m is a function of the meter design and is expected to be supplied by the meter manufacturer. When a full-flow end-of-line smokemeter is used, L_m is a function of the vehicle exhaust system and the way the meter is mounted on the tailpipe. Users of full-flow smokemeters must, therefore, determine L_m for each test conducted on a case by case basis.

Recognizing the wide variety of exhaust systems that may be encountered when conducting vehicle tests, this appendix provides guidelines which will assist full-flow smokemeter users in determining L_m. This appendix also includes suggestions for mounting full-flow meters on specific types of vehicular exhaust systems. Following these suggestions will facilitate the determination of L_m and will insure that proper smoke measurement principles are adhered to.

D.2 Determination of the As-Measured Effective Optical Path Length (L_m)

D.2.1 General Comments—The effective optical path length has been defined as "the length of the smoke obscured path between the smokemeter light source and detector." Portions of the light source to detector path length which are not smoke obscured do not contribute to the effective optical path length. If the smokemeter light beam is located sufficiently close to the exhaust outlet (within 7 cm or 2.76 in) the cross section of the smoke plume as it passes by the smokemeter is essentially the same as the tailpipe outlet and the effective optical path length is equal to the internal distance across the tailpipe outlet along the line of orientation of the smokemeter light beam. In general, this distance should be determined by direct measurement of the tailpipe outlet, and to achieve corrected smoke results which are within ±2% opacity or ±0.2 m^{-1} smoke density, this measurement should be made within ±5 mm (±0.197 in).

It is often difficult, particularly in roadside testing applications, to gain access to and obtain direct measurements of the tailpipe outlets on many vehicles. Fortunately, for many common tailpipe designs L_m can be determined with sufficient accuracy from external exhaust system dimensions which are more easily measured. The remainder of this section describes these cases and the principles and procedures that should be adhered to in determining L_m.

D.2.2 External Versus Internal Tailpipe Dimensions—Most tailpipes encountered on vehicles are constructed from metal tubing of various standard nominal sizes. Nominal tubing sizes are based on the tubing OD whereas it is the internal dimension of the tailpipe that dictates L_m. The difference between the external and internal tailpipe dimension is twice the tubing wall thickness which is typically about 1.5 mm (0.060 in).

Use of the external tailpipe dimension as the as-measured effective optical path length results in corrected smoke values which are slightly less than the true corrected smoke values (−1% opacity or 0.01 m^{-1} smoke density). In most cases, this small error is acceptable. However, in cases where extreme accuracy is required or where the tailpipe wall thickness is unusually large, the material thickness should be accounted for in determining L_m.

D.2.3 Straight Circular Non-Beveled Tailpipes—This is the simplest tailpipe design that may be encountered and is illustrated in Figure D1. In this case, the smokemeter light beam should be oriented such that it is perpendicular to and passes through the central axis of the smoke plume and is within 70 mm (2.76 in) of the tailpipe exit. If these guidelines are followed, L_m is equal to the tailpipe ID and can usually be adequately approximated by the tailpipe OD (see D.2.2).

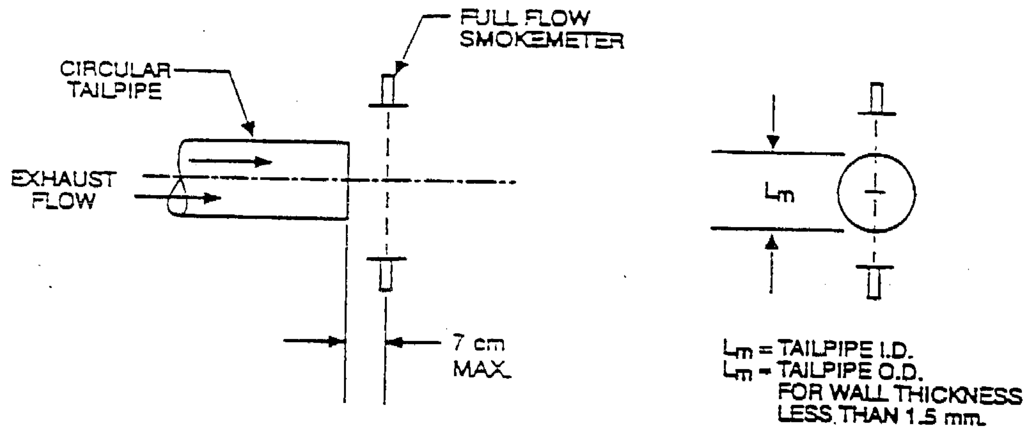


FIGURE D1—STRAIGHT CIRCULAR NON-BEVELED TAILPIPE

D.2.4 Straight Circular Beveled Tailpipes—A beveled tailpipe is formed when the outlet of the tailpipe is not cut off square (perpendicular) to the axis of the exhaust flow. When this type of tailpipe is encountered, there is only one recommended smokemeter mounting orientation. The axis of the smokemeter light beam should be perpendicular to and passing through the central axis of the smoke plume and should be parallel to the minor axis of the elliptical shape of the tailpipe exit. The smokemeter light beam must also be within 70 mm (2.76 in) of the tailpipe outlet (Figure D2). If these guidelines are followed, L_m is equal to the tailpipe ID and can usually be adequately approximated by the tailpipe OD (see D.2.2).

D.2.5 Curved Circular Tailpipes—When the central axis of the tailpipe is curved at the approach to the exit, the tailpipe is said to be curved and the cross section of the tailpipe outlet is non-circular. To avoid erroneously low readings when this type of tailpipe is encountered, the smokemeter should be mounted such that the axis of the smokemeter light beam is perpendicular to and passing through the central axis of the smoke plume (not necessarily the centerline of the pipe) and is parallel to the minor axis of the tailpipe exit. The smokemeter light beam must also be within 70 mm (2.76 in) of the tailpipe exit (Figure D3). If these guidelines are followed, L_m is equal to the tailpipe ID and can usually be adequately approximated by the tailpipe OD (see D.2.2).

Smokemeter orientations in which the smokemeter light beam is not parallel to the minor axis of the tailpipe exit may be used, but in these cases it will be necessary to determine L_m by direct measurement.

D.2.6 Non-Circular Tailpipe—If the tailpipe cross section is non-circular, the smokemeter should be mounted such that the smokemeter light beam is perpendicular to and passes through the central axis of the smoke plume and is within 70 mm (2.76 in) of the tailpipe exit. For these cases, L_m will need to be determined by direct measurement. If the tailpipe cross section is an oval or ellipse, it is recommended that the smokemeter light beam be aligned with either the major or minor axis of the tailpipe cross section in order to facilitate the measurement of L_m (Figure D4).

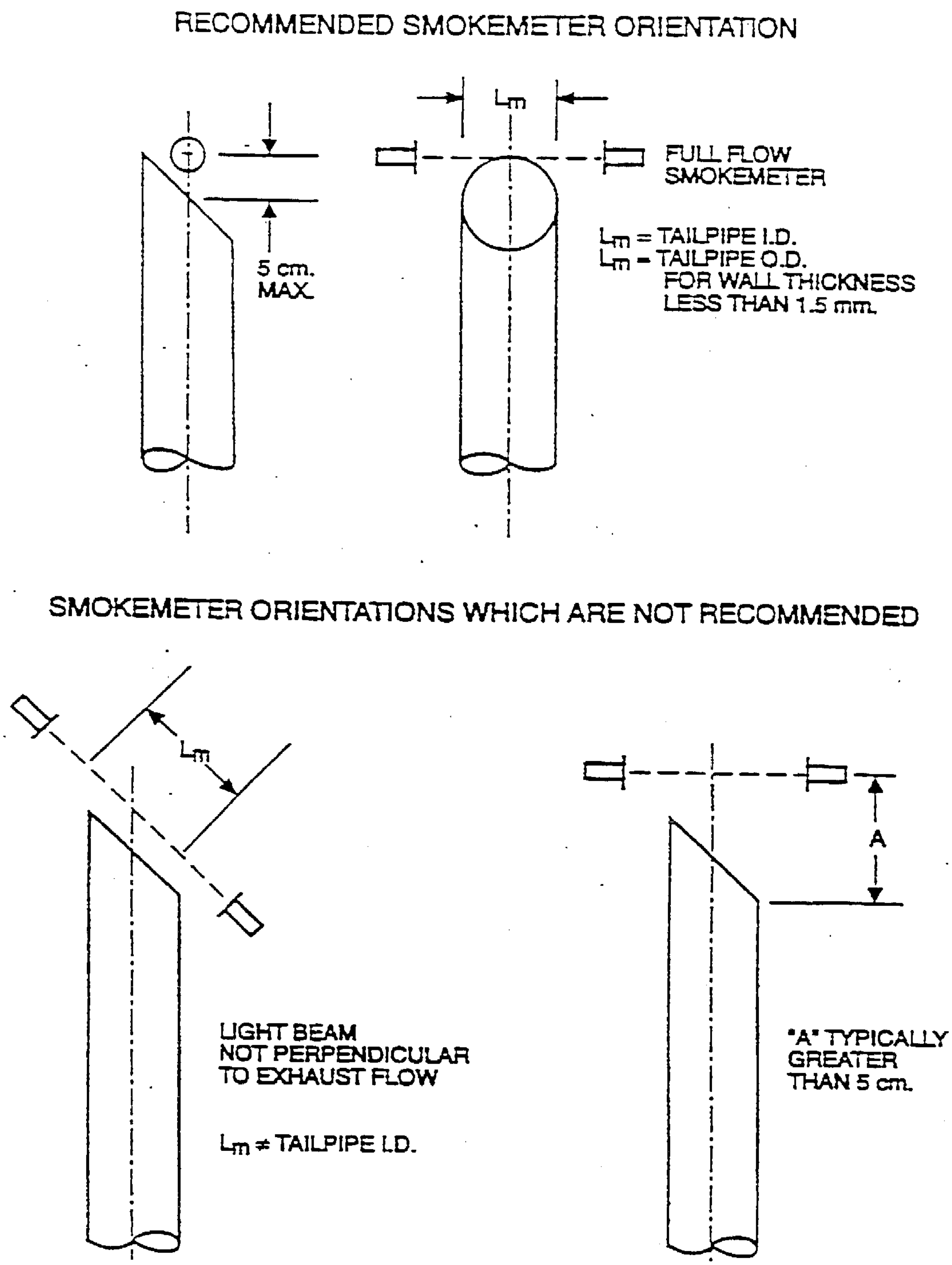
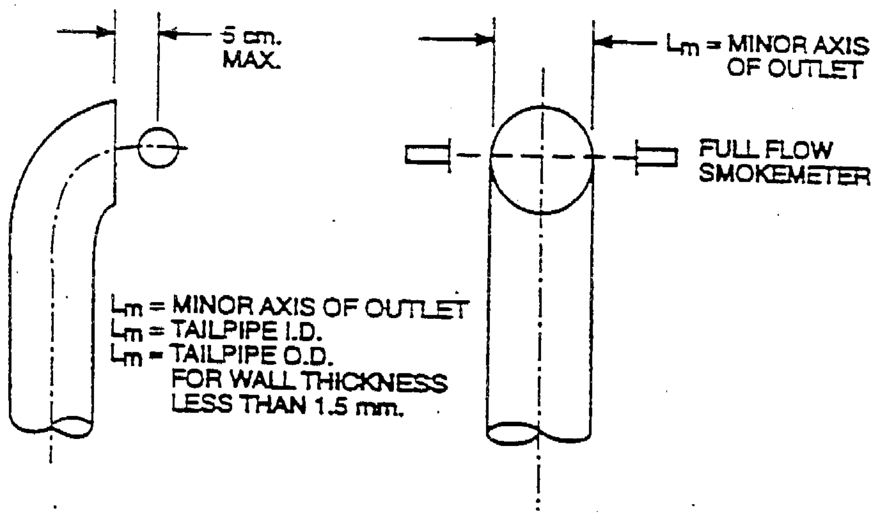


FIGURE D2—STRAIGHT CIRCULAR BEVELED TAILPIPE

RECOMMENDED SMOKEMETER ORIENTATION



ACCEPTABLE SMOKEMETER ORIENTATION

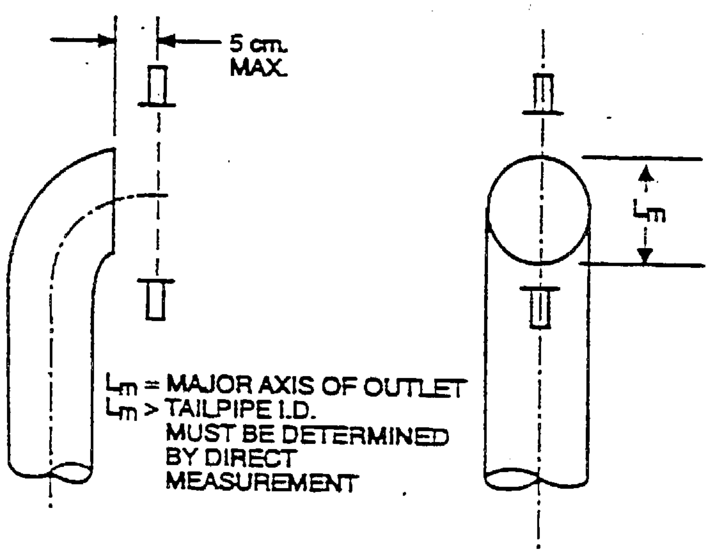
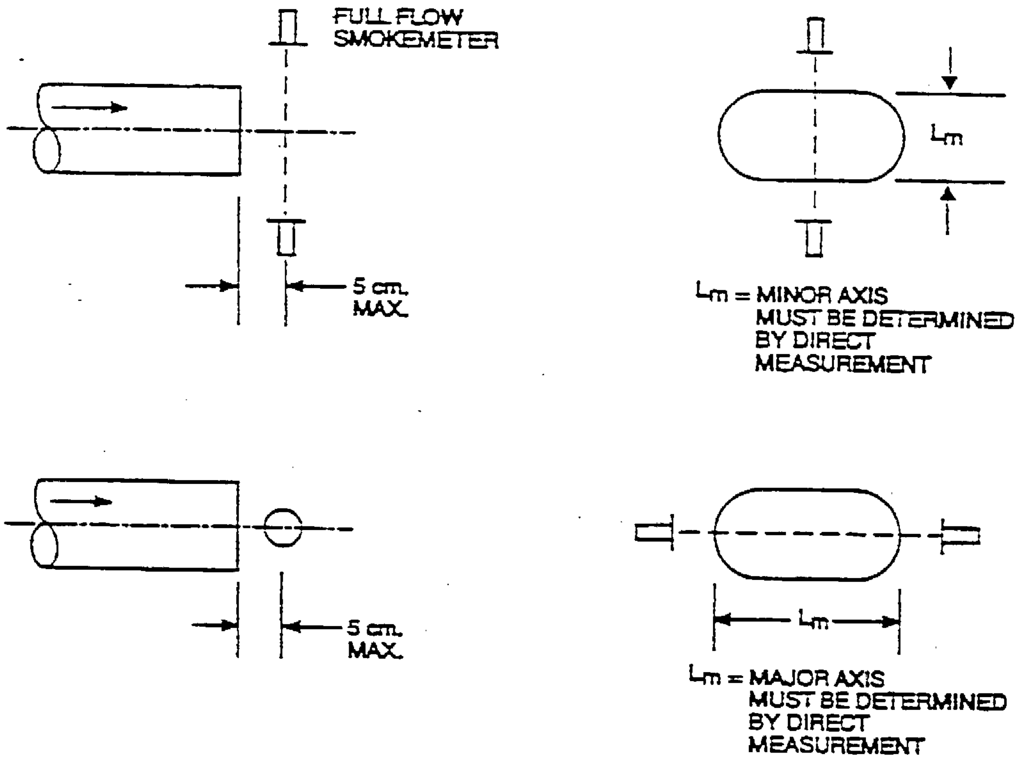


FIGURE D3—CURVED CIRCULAR TAILPIPE

RECOMMENDED SMOKEMETER ORIENTATIONS



SMOKEMETER ORIENTATION WHICH IS
NOT RECOMMENDED

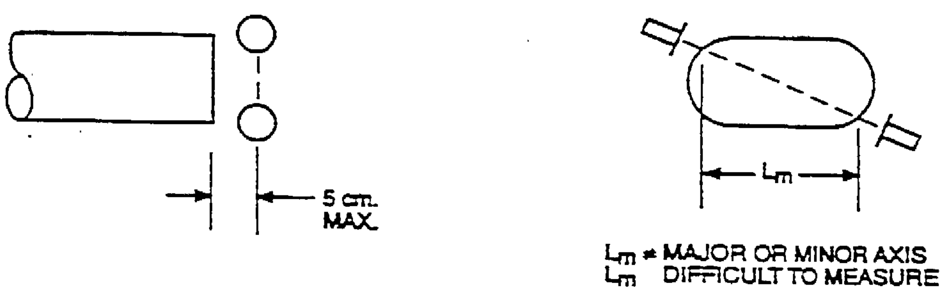


FIGURE D4—NON-CIRCULAR TAILPIPE

D.3 Other Conditions

D.3.1 Rain Caps—Smoke measurements cannot be performed using a full-flow end-of-line smokemeter when a tailpipe rain cap is operational. If present, rain caps must be removed or secured in the fully open position prior to smoke testing. If the smokemeter is installed without removing the rain cap, the meter must be oriented so that the cap does not interfere with the smoke plume or block any portion of the smokemeter light beam (Figure D5).

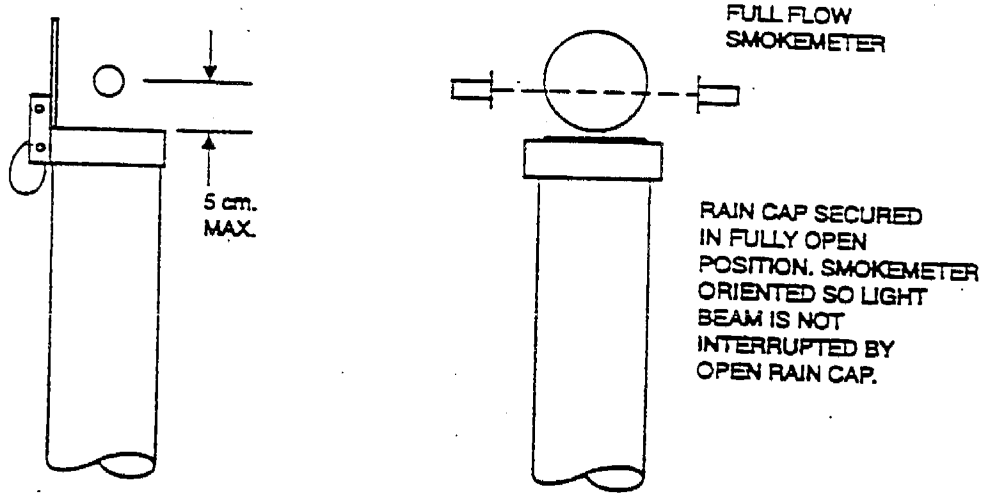


FIGURE D5—RAIN CAP

D.3.2 Downward Directed Exhaust—Many vehicles have horizontal exhaust systems affixed to the underside of the vehicle chassis. Typically these exhaust systems have a curved tailpipe which directs the exhaust flow down against the surface of the roadway.

Care should be exercised when using a full-flow end-of-line smokemeter with vehicles having this type of exhaust system. In some cases, exhaust gases can "rebound" off the roadway surface and recirculate through the smokemeter light beam causing erroneously high smoke measurements. This condition can be aggravated if road dust becomes entrained in the recirculating exhaust flow.

In most cases, little can be done to prevent this condition; however, it is recommended that testing personnel attempt to observe whether recirculation is occurring when testing vehicles with downward directed exhaust systems. If recirculation appears to be influencing the smoke measurement, the test results should be considered unreliable (too high) and should be used with caution.

Rationale—Not applicable.

Relationship of SAE Standard to ISO Standard—Not applicable.

Application—This SAE Recommended Practice applies to vehicle exhaust smoke measurements made using the Snap-Acceleration test procedure. Because this is a non-moving vehicle test, this test can be conducted along the roadside, in a truck depot, a vehicle repair facility, or other test facilities. The test is intended to be used on heavy-duty trucks and buses powered by diesel engines. It is designed to be used in conjunction with smokemeters using the light extinction principle of smoke measurement.

This procedure describes how the snap-acceleration test is to be performed. It also gives specifications for the smokemeter and other test instrumentation and describes the algorithm for the measurement and quantification of the exhaust smoke produced during the test. Included are discussions of factors which influence snap-acceleration test results and methods to correct for these conditions. Unless otherwise noted, these correction methodologies are to be considered an integral part of the snap-acceleration test procedure.

Reference Section

SAE J255a—Diesel Engine Smoke Measurement

SAE J1243—Diesel Emission Production Audit Test Procedure

SAE J1349—Engine Power Test Code—Spark Ignition and Compression Ignition—Net Power Rating

SAE J1995—Engine Power Test Code—Spark Ignition and Compression Ignition—Gross Power Rating

ISO CD 11614—Apparatus for the Measurement of the Opacity of the Light Absorption Coefficient of Exhaust Gas from Internal Combustion Engines

Code of Federal Regulations (CFR), Title 40, Part 86, Subpart I—Emission Regulation for New Diesel Heavy-Duty Engines: Smoke Exhaust Test Procedure

Procedures for Demonstrating Correlation Among Smokemeters

Developed by the SAE Heavy-Duty In-Use Emission Standards Committee

Attachment D

Project OutReach Notice

Cal/EPA

California Environmental Protection Agency

Air Resources Board
P.O. Box 2815
2020 L Street
Sacramento, CA
95812-2815

www.arb.ca.gov

Pete Wilson
Governor

Peter M. Rooney
Secretary for Environmental Protection

MAIL-OUT #MSO 97-08

DATE: October 15, 1997

TO: ALL HEAVY-DUTY DIESEL ENGINE MANUFACTURERS
ALL HEAVY-DUTY VEHICLE MANUFACTURERS
ALL HEAVY-DUTY DIESEL FLEETS
OTHER INTERESTED PARTIES

SUBJECT: **PROJECT OUTREACH TO ASSIST THE TRUCKING AND BUS INDUSTRIES**

The Air Resources Board is pleased to announce Project OutReach.

Project OutReach is the Air Resources Board's (ARB) endeavor to assist the trucking and bus industries in understanding and complying with the requirements of the roadside Heavy-Duty Vehicle Inspection Program and the Periodic Smoke Inspection Program for fleets. These programs are designed to reduce the number of excessively-smoking heavy-duty vehicles operating in California.

Project OutReach offers without cost or penalty:

- An on-site presentation and discussion of these programs to fleets and associations by ARB staff;
- A demonstration of the new Society of Automotive Engineers (SAE) J1667 "snap-acceleration test procedure" on any vehicle you request;
- A smoke inspection using the new SAE J1667 snap-acceleration test procedure "in the field" (such as at some California Highway Patrol weigh stations and random roadside locations);
- A printed report on the smoke level of any truck tested.

Enforcement of these programs will resume in the spring of 1998. At that point, an excessively-smoking truck or bus could be fined up to $1,800. Project OutReach offers you an opportunity to test your vehicles and bring them into compliance before the fact.

In addition, you may be interested in learning more about the California Council on Diesel Education and Technology's (CCDET) technician-training courses, and the American Trucking Association and Engine Manufacturers Association's joint project "On the Road to Clean Air".

To obtain any of these educational materials, or to schedule a Project OutReach appointment, please contact:

In Southern California
Southern Heavy-Duty Diesel Section
9528 Telstar Avenue
El Monte, California 91731

Attention:
Mr. Ramon Cabrera
(626) 450-6177
e-mail:rcabrera@arb.ca.gov

or

Ms. Hortencia Mora
(626) 450-6161
e-mail:hmora@arb.ca.gov

In Northern California
Northern Heavy-Duty Diesel Section
2020 L Street
Sacramento, California 95814

Attention:
Mr. Robert Ianni
(916) 322-0845
e-mail:rianni@arb.ca.gov

or

Ms. Sharon Johnson
(916) 322-8275
e-mail:sjohnson@arb.ca.gov

Sincerely,

Paul E. Jacobs

for R. B. Summerfield, Chief
Mobile Source Operations Division

Attachment E

Summary of Litigation Challenging the California Heavy-Duty Vehicle Inspection Program

SUMMARY OF LITIGATION CHALLENGING
THE CALIFORNIA HEAVY-DUTY VEHICLE INSPECTION PROGRAM

The Heavy Duty Vehicle Inspection Program (HDVIP) regulations (§§ 2180-2187, title 13, California Code of Regulations) became effective on November 21, 1991. The regulations authorize inspectors of the Air Resources Board (ARB or Board) to inspect heavy-duty vehicles and issue citations for excessive smoke. The regulations provide that the opacity of smoke emitted by the vehicles is to be measured by a "snap-idle" test. Opacity as measured by the snap-idle test generally may not exceed either 40 or 55 percent, depending on the age and characteristics of the vehicle.

Companion regulations (§§ 60075.1 - 60075.47, title 17, California Code of Regulations) provide for an administrative review of any issued citation. Decisions of the administrative hearing officer may be challenged in state court pursuant to California Code of Civil Procedure (CCP) section 1094.5. CCP section 1085 allows persons to challenge regulations adopted by a state agency on the ground that they are arbitrary, capricious, or lacking in evidentiary support. It also authorizes courts to enjoin future enforcement of invalid regulations.

As of October 1997, four different lawsuits have been brought challenging the HDVIP. In each case, counsel for the California Trucking Association (CTA) have represented the plaintiffs. At each level in each case, the courts have ruled against the plaintiffs bringing the lawsuits.

I. *Valley Spreader Inc. v California Air Resources Board*, Imperial County Superior Court Case No. 72969 filed December 30, 1991

This first legal challenge to the HDVIP regulations was filed on December 30, 1991 by a operator of heavy-duty vehicles in Imperial County. The plaintiff asked the court to invalidate the HDVIP regulations. A five-day hearing was conducted by the court intermittently during October and November 1992. After considering the evidence presented by the parties, on May 5, 1993 the Imperial County Superior Court ruled as follows:

1. The ARB had authority to adopt smoke emission standards for in use on-road heavy-duty diesel-powered vehicles.

2. The ARB complied with all procedural requirements in adopting the regulations.

3. The regulations were supported by substantial evidence and were not arbitrary and capricious.

4. The 40 and 55 percent cut points were reasonably substantiated before being enacted by the Board.

5. The snap idle test was not chosen in an arbitrary or capricious manner.

6. The data used to determine the smoke opacity cut point was reasonably selected based on data collected from the ARB pilot study.

7. The *Kelly*[1] evidentiary rule was not applicable to the introduction of snap idle-test results in the HDVIP administrative hearings.

The plaintiffs chose not to appeal the *Valley Spreader* decision.

II. ***Harris Transport et al. v. California Air Resources Board***, Sacramento County Superior Court Case No. CV374301 filed April 29, 1993, *appeal denied* January 31, 1995, 32 Cal.App.4th 1472.

The *Harris* case was brought on behalf of ten trucking companies who were issued citations for excessive smoke. They challenged the citations in administrative hearings, asserting that the smoke test results were not admissible under the *Kelly* rule. The hearing officer upheld the citations. In their Petition filed with the Sacramento County Superior Court on April 29, 1993, the plaintiffs raised many of the same issues raised in *Valley Spreader*. They asked the court to order the ARB to set aside the decisions on the individual citations, and to enjoin the ARB from enforcing the HDVIP program in the future.

Sacramento Superior Court Judge James Ford denied the petitions after a July 30, 1993 hearing, and the plaintiffs appealed this ruling to the California Third District Court of Appeal. In a January 31, 1995 published decision, the Court of Appeal affirmed Judge Ford's ruling. The court directly addressed and rejected the plaintiffs' argument that the *Kelly* rule applied to the admissibility of snap-idle test results in citation hearings. Because the regulations identify standards for opacity *as measured by the snap-idle test*, the test results are introduced not to scientifically prove a particular opacity level but rather to establish the results of the snap-idle test. The court explained:

> Whether the snap-idle test is scientifically accepted as an accurate measure of vehicle emissions is not the relevant issue at this juncture. Rather, it is whether the plaintiffs' vehicles failed the test prescribed by the Board, i.e. the snap-idle test. If a vehicle fails the snap-idle test, it is in violation of Board regulations and the owner is subject to citation. In this context, *Kelly* is inapplicable. (32 Cal.App.4th 1472, 1479.)

While the *Harris* plaintiffs had originally claimed that the HDVIP regulations were

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[1] The "*Kelly*" rule (formerly called the "*Kelly/Frye*" rule) sets the evidentiary standard for determining the admissibility of evidence from new scientific techniques in the state courts. In *People v. Kelly* (1976) 17 Cal.3d 241, the California Supreme Court held that in order for scientific evidence to be admissible, the prosecution must show "general acceptance of the new technique in the relevant scientific community." This rule is applied to the use of "lie detector" tests, for instance, which are not admissible as "proof" of a person's truthfulness or guilt.

unlawful, the Court of Appeal found they had abandoned this challenge at the hearing before the trial court and "had conceded the regulations had been properly adopted." (*Id.* at 1480). The plaintiffs had also abandoned any claims the tests had been improperly conducted. (*Id.*) Finally, the court held that the plaintiffs were not entitled to consideration of an order enjoining future enforcement of the HDVIP program, because the plaintiffs have the option of raising their claims at future citation hearings.

Dissatisfied with the Court of Appeal's decision in *Harris*, the plaintiffs filed a Petition for Rehearing on February 14, 1995 which the court denied on February 24, 1995. The CTA attorneys then filed a Petition for Review with the California Supreme Court on March 10, 1995. The Supreme Court denied the petition on April 19, 1995, thereby ending the litigation of this case.

III. ***Aura Hardwood v. Air Resources Board***, Sacramento County Superior Court Case No. CV377421 filed March 11, 1994, *appeal denied* August 31, 1995 (3rd Cir. No. C019826)

Shortly before the California Supreme Court denied the final *Harris* appeal, on March 11, 1994 the CTA attorneys filed this new lawsuit challenging the HDVIP program. The *Aura* plaintiffs were 12 owners of heavy-duty trucks whose citations had been upheld following administrative hearings. The hearing officer denied the plaintiffs' argument that the *Kelly* rule applied to introduction of the smoke test results, and also denied their claim that the HDVIP regulations are invalid. The *Aura* plaintiffs sought a writ of mandate from the Sacramento Superior Court commanding the Board to: (a) stay the enforcement of the HDVIP, (b) stay review by the administrative hearing process, and (c) ban the use of the snap idle test procedure. Once again Sacramento Superior Court Judge Ford denied the petition after a full hearing on October 21, 1994.

The *Aura* plaintiffs then appealed Judge Ford's determination to the Third District Court of Appeal. On August 31, 1995, the appellate court again upheld the validity of the Heavy Duty Vehicle Inspection Program. Citing the *Harris* decision, the *Aura* court held that the *Kelly* rule does not apply to the use of smoke test results to demonstrate a smoke violation in the HDVIP. However, the *Aura* court also held that the *Aura* plaintiffs had preserved their challenge to the legality of the underlying regulations. The Court of Appeals considered the plaintiffs' arguments and then upheld the regulations. First, the court rejected the plaintiffs' "false premise that the Board's rulemaking proceedings are subject to the evidentiary requirements of *Kelly*." Noting the statutory qualifications for appointment to the Board, the court stated, "there is no need to protect the Board members from being misled by scientific evidence." (Slip op. at 12) The court then concluded,

> The record in this case reveals that the Board acted within the scope of its authority and its action adopting the HDVIP regulations was not arbitrary, capricious, or lacking in evidentiary support. We therefore conclude the [trial] court was correct in deferring to the Board's expertise and denying the petition for writ of mandate under Code of Civil Procedure sections 1085 and 1094.5. (Slip

op. at 13)

Finally the court held that the 1993 amendments to Health and Safety Code 44011.6 did not affect the validity of the HDVIP regulations. Unlike *Harris*, the *Aura* decision was not certified by publication. This means that it does not serve as precedent in future lawsuits.

The CTA attorneys petitioned the Court of Appeal for a rehearing, and the petition was denied on September 26, 1995. They next petitioned the California Supreme Court for review, and that petition was denied on November 15, 1995.

IV. ***Viviano Trucking v. California Air Resources Board***, Sacramento Superior Court Case No. CV376933 filed January 14, 1994, *appeal pending* Third Cir. No. C026354

The initial Petition in this case, involving a total of 290 plaintiffs, was filed before the *Aura* petition and raised most of the same issues. In October 1994 the trial court stayed the *Viviano* proceedings until completion of the *Aura* case as it was thought that the *Aura* decision could resolve the *Viviano* issues. However, after *Aura* was decided in favor of the ARB, on June 14, 1996 the CTA counsel filed a First Amended Petition in *Viviano*. The First Amended Petition raised both old and new claims — that the *Kelly* rule applied both to admission of test results at administrative hearings and adoption of the HDVIP regulations, that the authorizing statute (Health and Safety Code §44011.6) and the inspectors' practices violated the constitutional rights of the plaintiffs to be free from illegal searches and seizures, and that the authorizing statute violates the plaintiffs' constitutional right to be free from vague legislation. The "constitutional" issues had generally not been raised by the plaintiffs' CTA counsel at the administrative hearings.

The *Viviano* First Amended Petition came before Judge Ford on March 7, 1997, at which time he denied the petition. The CTA counsel then filed a notice of an appeal to the Third Appellate District of the Court of Appeals — the same court that had rejected the appeals in the *Harris* and *Aura* cases. The Appellants' Opening Brief was filed on August 7, 1997, and the ARB filed its Respondents' Brief on September 10, 1997.

Attachment F

Technical Support Document
(order form)

Fold

Please send a copy of the
Technical Support Document

for the Proposed Amendments to the California Regulations Governing the
Heavy-Duty Vehicle Inspection Program (HDVIP)
and the
Periodic Smoke Inspcetion Program (PSIP)
to:

Name:
Address:
City, State, ZIP:

Fold

California Environmental Protection Agency

Air Resources Board

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Heavy Duty Diesel Section
P. O. Box 2815
2014 Capitol Avenue
Sacramento, CA 95812

Attention: Debra Parr